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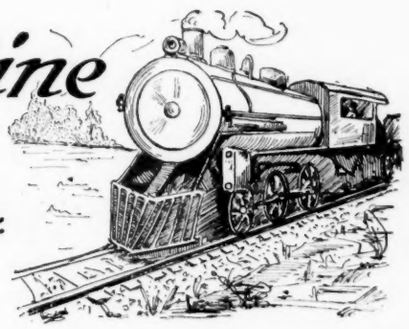
Andy's Engine

By

James T. Beard, Jr.



THE character of a musician is reflected in his sonatas; an architect, in his buildings; a poet, in his verses. The individuality of every man creeps into his work, and by his work we judge him. The boiler room furnishes a mirror, reflecting the character of a chief engineer. The heat that he is able to squeeze out of the coal and into the steam is the true standard of his capabilities, but a quick indication of his intelligence is the care that he takes of the equipment for squeezing out this heat.

I was standing at the station in a typical small Jersey town, waiting for a train to carry me back to the city. Presently I heard the welcome sound of a whistle far down the track. The station attendant ran out with a few mail bags, and I picked up my grip, glad that my half-hour wait was over.

As the train approached it seemed to me that it was not going to stop. I was not acquainted with the schedule of the road, so I asked the boy, "Does this train stop, or is she an express?"

He looked up, surprised. "Don't you know that engine?"

I explained that I was not an authority on locomotive engines in the country.

He looked at me with a sort of pity for my ignorance. Then he pointed down the track. "See the way she shines when the sun hits her? That's Andy's engine. I'd know her in a thousand. He takes care of her just as if she was his own."

The train stopped. I climbed aboard and settled down in my seat. The boy's words still haunted me: "I'd know her in a thousand. He takes care of her just as if she was his own." This youngster had unconsciously given a wonderful testimony to Andy's ability as an engineer and character as a man. "He takes care of her just as if she was his own." In these few words he had written for Andy the best recommendation in the world.

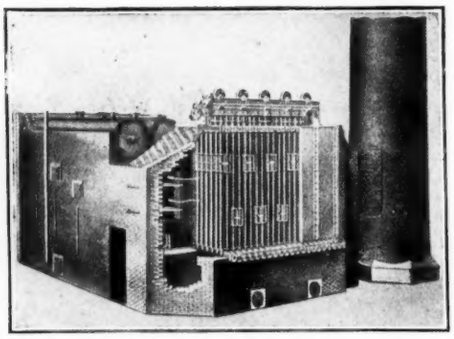
I began to think of some of the boiler rooms I had seen during the past month. Ashes from the last cleaning could still be found around the ashpit doors. Steam hissed from leaky joints and fittings. Hot water dropped down my back from the maze of steam piping overhead, no matter where I stood. Draft gages were covered with dirt, leaving the scale entirely hidden from view. Sometimes they had oil; more often they had not. Many recording instruments hadn't operated since no one knows when. And there was always trouble. Coal was bad, steam was down, men were dissatisfied and quitting.

Then I thought of a plant that I had visited just the day before. The nickel draft gages are polished faithfully every day. The glasses are clean and I can read the scale twenty feet away. The recording instruments tick off the flue-gas temperatures and CO_2 percentages every day in the year. The glands of the feed pump are well packed. The boilers are clean inside and out. The atmosphere of the boiler room is healthy and the floor looks like Sunday. I always love to visit this plant. The coal is good, the steam is always there when it is wanted, the men are happy and there is no trouble.

Two kinds of plants have been cited. The difference between them is not a matter of better equipment. The acid test of a chief engineer is that he get the most out of existing equipment. It is not a matter of labor troubles at the plant. A capable chief can handle his men. It is not so much a matter of poor coöperation from "the men upstairs." An intelligent chief will command respect and coöperation. The difference between them is a difference in the men that operate and care for them.

The boiler room reflects the character of the chief just as surely as water reflects the sky. Give me one look at the draft gages on the boilers and I will tell you the caliber of the chief engineer. Not because a polished draft gage means higher CO_2, lower flue-gas temperature or better economy, but it indicates care and pride on the part of the man in charge. It means that the details are being watched.

The man who sees that a draft gage is polished will see that a leaky blowoff valve behind the boiler is repaired. He will see that the cracks in the setting are plugged up. He will see that leaky joints in the steam line are made tight, a leaky trap is repaired. He has time to set the valves of his engines. He takes care of the plant "just as if she were his own."



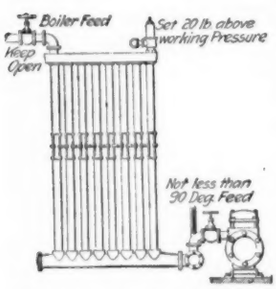
Care of Economizers

By J. F. DAGGETT*

Some Helpful Suggestions as to the Operation and Care of Economizers, Probably the Most Neglected Apparatus in the Boiler Plant

ON ACCOUNT of the coal shortage and the high cost of fuel, economizers have been installed in most steam-power plants erected in the last three years. As many of the men in charge of these will be using economizers for the first time, it may be well to go over the essential points pertaining to their operation and care.

There is probably no boiler-house adjunct that pays a better return on the investment than the economizer, and it is probably the most neglected apparatus installed. The reason why economizers are usually neglected is that they are installed in out-of-the-way places and receive attention only when something goes wrong. This neglect is not intentional, but happens principally because there is so little trouble experienced with this apparatus. I have inspected many of the installations in the United States and Canada, and on several occasions have heard the chief engineer complain that he was not getting the results that he thought he should get from the machine. On investigation, it was found that in almost every instance the trouble was due not to the machine, but to the men in charge in not giving it the proper attention. In view of the foregoing a few suggestions as to the operation and care of economizers may be helpful.



An economizer should not be fed with water at a temperature lower than 90 deg. F. Colder water causes condensation on the lower portion of the tubes and on the bottom headers, which results in rapid external corrosion. The soot also becomes baked hard on the tubes and prevents the scrapers from working.

A relief valve set at 20 lb. in excess of the working pressure on the economizers should be placed on the feed pipe between the pump and the economizer. This will take care of excessive pressure built up by the pump. The outlet valve between the economizer and the boilers should always be kept open. The furnace draft should be regulated by the main damper at the outlet end of economizer, and not by the boiler dampers. The latter should be used only in case a boiler is laid off or when the economizer is shut down. Care should be taken to prevent cold air from leaking into the main flues by making all crevices in the brickwork air-tight.

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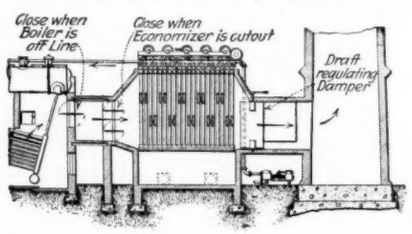
The economizer should be blown off for a few minutes daily, both at the top and bottom, through the safety and blowoff valves. The tail pipe from the blowoff valve should fall evenly to the drain, thus enabling the apparatus to be emptied when necessary.

The safety valve should not be set more than 20 lb. in excess of the working boiler pressure. All valves, and especially the safety valve, should be carefully examined weekly, and all waste water delivered so that it will not drain into the soot pit, flues, or cleaning-out space.

The scrapers should be kept constantly running when the economizer is in use. The cross-shaft carrying the clutch-box should run at 55 revolutions per minute. If the scrapers stick, remove the setscrew connecting the chain pulley and the wormwheel and, by means of a handle on the pulley spindle, work the scrapers up and down until they run freely. The chains and chain wheels must not be allowed to become greasy or they will slip. After a time the chains stretch slightly and should be shortened so that the scrapers may traverse the whole length of tubes. When the chains get worn, turn them around on the pulleys.



Thermometers, pressure gages and pyrometers should be placed at both ends of the economizer and readings should be taken daily. In this way the internal condition can be noted; that is, if there is falling off in efficiency, the temperature of the water and gas remaining the same, it will show that the economizer needs to be cleaned, as there is some cause preventing the proper transmission of the heat of the flue gas to the water. This is due to dirt either inside or outside of the tubes.

If the feed water should contain lime, salts or other impurities, and an anti-incrustation fluid is used, it should be introduced by means of a small injecting pump into the feed pipe before entering the economizer. The vertical tubes and the bottom headers should be examined and cleaned internally at least every

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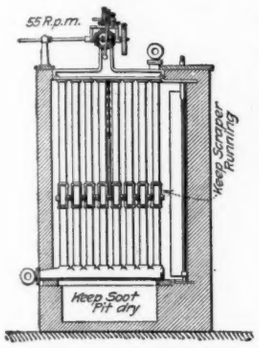
twelve months. Do not allow the soot chamber below the economizer to get too full. It should be cleaned out at least once a month. The space between the vertical tubes, bottom headers and side walls should also be thoroughly cleaned. Any dampness in the flues, foundation or soot chambers should be remedied on discovery.

If the water in the economizer gets too low, immediately open the bypass flue damper and close the economizer inlet damper, leaving the outlet wide open. Also open the direct boiler-feed valve and close the inlet and the outlet economizer feed valves. Remove covers from the soot-pit manholes and open all doors into the economizer chambers. Do not touch the safety valve until the tubes are cool.

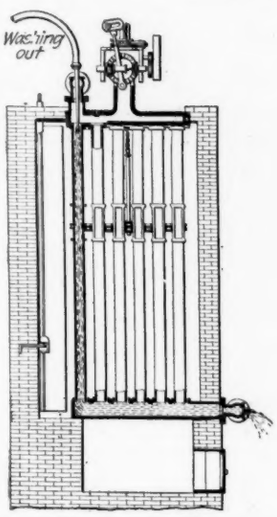


Economizers located in exposed places, when not in use, should be emptied in frosty weather.

To shut down an economizer open the bypass flue damper and close the inlet and outlet economizer dampers, also open the direct boiler-feed valve and close the inlet economizer feed valves.

When it is necessary to clean an economizer internally, all the internal caps should first be removed; then it will be possible to clean the tubes either with the hand scraper or by a water-driven turbine cleaner. The latter method is quicker and also has the advantage of the water flowing through the tubes, carrying the refuse with it.

When cleaning an economizer, be careful to open the blowoff and relief valves, also knock in several internal caps in different parts of the machine. Then open both inlet and outlet dampers, allowing the hot gases to pass through the economizer chamber and around the tubes for a period of about twenty minutes. During this time be sure to keep the scrapers operating.



If, after doing this the tubes are found to be still dirty, it will be necessary to burn them off, but this method requires a man trained for the work and it is much better to apply directly to the economizer company for a man who is familiar with the process. The foregoing covers the essential points in the operating and care of economizers. Repairs are better treated individually, as the types of economizers vary somewhat and when repairs are necessary, it is best to get a man from the manufacturers who is expert and experienced in this kind of work.

Carelessness in Refrigerating Plants

By E. W. MILLER

The author tells in a vivid way of some of the careless acts done in refrigerating plants, resulting in suffering and death to the operatives. Usually, the carelessness of one man is responsible for the suffering of many others. Leaving a coil or receiver full of cold liquid ammonia, with no opportunity to expand, suddenly breaking pipe joints and "spinning" valves shut are causes of serious accidents.

THE careless man is probably more of a menace in a refrigerating plant than in any other branch of power-plant engineering, as a large volume of ammonia gas suddenly let loose can prove more disastrous to human life than a boiler explosion. In an electric plant he is often more of a menace to himself than to others, because workmen as a general rule can take sufficient precautions to protect themselves. In the refrigerating plant, however, this is not so truly the case.

Some trouble had been experienced with the expansion valves on one of the coils in a large beef cooler in a packing-house plant. It happened to be on a very cold day and the ammonia leaving the condenser, which was of the atmospheric type and located on the roof where the wind had a good chance at it, was cold enough so that even the liquid receiver was slightly frosted.

The liquid line and the coil on which the defective expansion valve was located were pumped out, the valve cleaned out, a bit of packing being the cause of the trouble. Pumping out the liquid line of course reduced it to a low temperature and further reduced the temperature of the liquid when it was again turned into the line. The expansion valve on the coil which had been repaired was opened until all the gas and air were out, as determined by the sound in the valve. It was then shut off because the cooler at this time was below the required temperature.

For reasons best known to himself the assistant engineer who directed the repair job shut off the stop valve in the main liquid line some distance back from the expansion valve. About noon men began to load the cooler with freshly killed beef, and the temperature climbed rapidly from about 29 deg. to about 48 deg. before the temperature man knew of the loading.

A freshly loaded beef cooler is as hard to find one's way about in as is a densely foggy morning, and the temperature man groped his way through the rows of hanging beeves to the back of the room, where the expansion valves were located. There were some five or six other men in the cooler at the same time. About the time that the temperature man had reached the rear of the cooler a gasket in one of the liquid line joints near the cooler exit blew out, and the liquid in the line, expanding as in normal operation in the coils from the heat in the room, rushed out through the opening.

The leak was directly in front of the door, and it was impossible for anyone to get past it without being sprayed with the escaping liquid. The men, terror-stricken, had to back up into the rear of the cooler. The temperature man, on being informed of the accident, opened all the expansion valves, which were close together, hoping by this means to reduce the pressure in the line somewhat and thus reduce the leak. In this he was more successful than he had expected, because he was not aware that the line was shut off.

The air became insufferable, however, except near the floor, which all of them hugged as closely as possible while they yelled for help. Finally one of the men remembered where a door had been nailed up recently and all crawled along the wall until they found the door. Then getting a full breath they would hold it while they jumped up and tried to ram the door. They had to work quickly as they were winded in a few moments and breathing was impossible while standing even partly erect. Two of them finally collapsed when the other four, getting desperate, made one last attempt and finally rammed the door open. Two more collapsed just outside the door, and the other two had just enough energy left to drag out into the other room the two who had collapsed. Three of them were unable to do anything for nearly six weeks.

The accident was due to the engineer shutting off this section of the line at both ends. The cold ammonia in the line expanded to a very high pressure when the room warmed up and, as it was a solid block of liquid with no chance for relief, something had to let go—in this case the gasket. Fortunately, no one was killed, but only the resourcefulness of the men saved their lives. Liquid in the ammonia system should never be shut off so that it has no room for expansion. Always leave some outlet open for relief.

In another plant a gang of men were painting the ceiling and girders. At this time they were working directly above two 200-ton vertical machines. Trouble developed with the packing on one of the machines, and the chief decided to shut it down, pump it out and repack it. After it was stopped, he ordered one of the assistants to go out on the condensers and shut off the stop-valve in the discharge line of this machine at the condenser.

The assistant was one of those fellows who does a thing first and thinks about it later. Grabbing the stop valve, he gave it a spin that sent it shut at once. A series of reports, like those of a small gun, followed inside the power house and he hastily opened the valve again. The shock created by such manipulation of the valve broke some joints in the line, liberating ammonia. When he got back into the power house, the crew were carrying one of the painters down from the deck of one of the machines and were working over another on the floor. The painters had been unable to find their way down and finally some of them had dropped from the scaffold above the machines down on the deck when they were overcome with the fumes.

A large condenser had been shut down for repairs. On the day that work was to be started, it was pumped out thoroughly, but some other work turned up and nothing was done until the next day. In the morning the steamfitter and his helper asked for another pumping on the condenser to make sure that it was clear. The assistant engineer to whom he made his request, however, laughed at him and chided him for being too careful. The steamfitter refused to go to work on the condenser, however, until he had gained his point, and sat down and waited for the chief to appear. The assistant became peeved at this disregard of his advice and authority and, grabbing a couple of wrenches and a hammer, went out in the condenser shed to break open a joint to show the old steamfitter that he was too cautious.

Someone passing the shed heard him hammering at something and there was a sudden report and roar, as if a steam pipe had burst. The men who rushed to the scene tried to get inside the room, but the ammonia fumes were so dense that the men were blinded the moment they stuck their faces inside the door. Finally, one of them with a gas mask managed to get inside and drag the man out. He was dead.

One of the valves connecting this condenser with one of the others had leaked sufficiently to practically fill the condenser with gas up to probably full condenser pressure. The man had evidently removed all the bolts in the joint which he went to open and then hit it with a hammer, when the joint had sprung wide open. He had probably been directly in the path of the escaping fumes.

Ammonia joints should never be broken in a hurry and never without having first provided an opportunity for escape in case the fumes should become excessive. Loosen up each just a little and then gradually gently work the joint open with a chisel or other device. If then there is pressure on the joint, there is at least plenty of time to get away, and generally it can be tightened up again before the fumes become dangerous.

In another case a large triple-pipe brine cooler had frozen. After the trouble had been located, the engineer shut off the cooler both at the expansion valve and on the suction end. He then proceeded to thaw it out by blowing steam on and into it. It stopped the operation of one of the departments, and quite a number of the men came down into the engine room to find out about it. The cooler was in a small compartment by itself, and the whole crowd was inside watching the performance.

Suddenly, one of the flanges cracked and a stream of ammonia liquid shot out. It was only a few feet from the entrance to the compartment, and some of the men were nearly strangled before they got out.

The engineer was further back in the room, and the clouds of steam prevented him from noticing the leak until the gathering fumes warned him. By this time they were so strong that he was blinded before he could reach the door; probably he never would have got out if one of the oilers had not gone in with a gas mask and partly dragged him out.

The trouble in this case, the same as the one related in the beginning of this article, was due to the cooler having entirely filled with liquid when the cooler froze. Shutting it off on both ends left no room for expansion, and when the steam was turned long enough to warm up the liquid in the cooler, the pressure became so great that something had to let go.

Load Division Between Induction-Type Frequency Changer Sets

By QUENTIN GRAHAM

IN A RECENT article in *Power*, "Load Division Between Synchronous Frequency Changers Operating in Parallel" (Oct. 8 and Oct. 22, 1918), the load division between frequency changer sets of the synchronous type operating in parallel on both ends was discussed in detail. It is the purpose of this article to discuss the corresponding problem which arises when two induction-type frequency changers are operated in parallel. The term induction type as used here refers to a motor-generator set consisting of an induction motor and a synchronous generator, Fig. 1.

The problem of load division between frequency changer sets of this type is much simpler than the problem of load division between synchronous sets. In fact the problem is the same as that encountered in paralleling engine- or turbine-driven alternators.

In the article already referred to, it is shown that alternators in parallel driven by engines or other prime movers divided the energy load in accordance with the speed-load characteristics of the prime movers. That is, each prime mover delivers a certain definite amount of power at each speed, and since the speeds of the

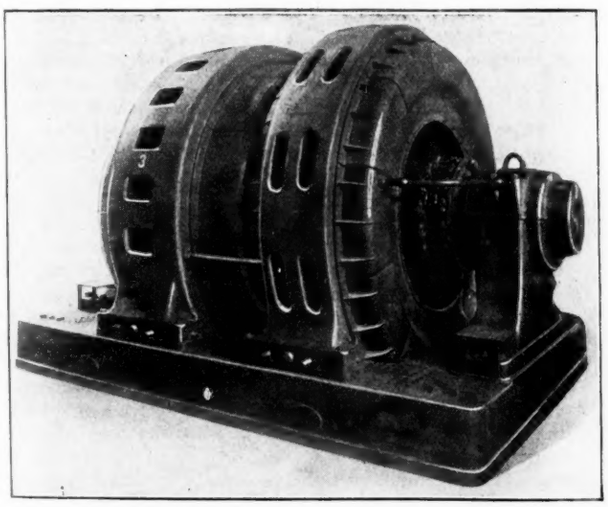


FIG. 1. INDUCTION-TYPE FREQUENCY-CHANGER SET

two paralleled units must be the same at all times, assuming alternators of the same number of poles, the output of each unit is determined by the speed-load curves. The same reasoning applies to alternators driven by induction motors.

Each of the motors has a speed-load curve which is practically a straight line over the working range, as shown in Fig. 2. The speed curves shown here are for two motors of different capacities, and the reduction in speed, or slip, shown by each curve is 6 per cent. at the rated output of the motor. At any other slip the proportion of load carried by each machine is the same. Thus if each motor has the same speed as the other at all times, the proportion of load which each carries is fixed. Since the generators, which are driven by the motors, are in parallel the units must have the same speeds at all times. It is to be understood, of course, that if the motors have not the same numbers of poles their speeds are not the same but have a constant ratio at all times.

In order to change the proportion of energy load carried by each set, the speed-load curves must be changed. With engine-driven units the speed-load curves may be changed by means of the governor and the division of load may be controlled. With induction motors something analogous to an adjustment of the governor may be accomplished by varying the secondary

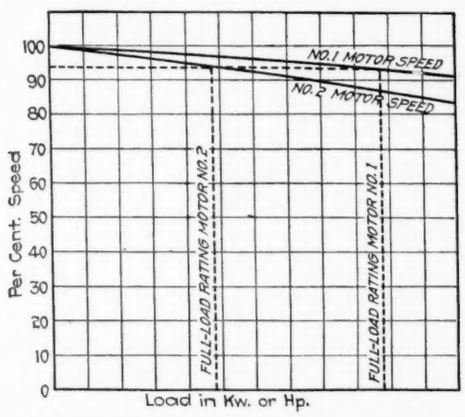


FIG. 2. CURVES SHOWING RELATION BETWEEN INDUCTION MOTOR SLIP AND LOAD

resistance. With increased secondary resistance the speed curve has a greater slope so that the drop in speed for a given load must be greater. Thus if one or both of the motors of two induction-type sets have wound secondaries, so that the resistance can be varied, the division of energy load may be controlled.

A change in the excitation of the generators has the same effect as with engine-driven machines. The power factor of each machine can be changed; one machine can be made to carry more or less of the reactive or wattless component of the load, depending upon whether its excitation is increased or decreased. Such variations in excitation have no effect whatever upon the energy component, however, since this depends entirely upon the speed curves of the motors.

In the discussion of synchronous sets it was shown that changes in excitation have a decided effect upon load division. It was also shown that by shifting the frame of one of the machines circumferentially the division of load could be changed. With an induction-type unit such a procedure has no effect whatever, since there is no fixed phase relation between the induction-motor rotor and the supply circuit. To insure satisfactory parallel operation of induction-type sets, therefore, it is necessary that the per cent. slip, or speed decrease at rated load, be the same for all motors.

Revision of A. S. M. E. Boiler Code

Part I, Section I

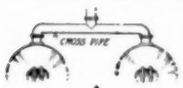
A REVISED edition of the 1914 Boiler Code has just been issued by the American Society of Mechanical Engineers and represents the work of the Code Committee during many meetings extending over a period of about two years. A number of changes have been made in the rules. This article will attempt to point out the changes and corrections that will be of interest to manufacturers and inspectors of boilers or others who are interested in the application of these rules as regards the construction of boilers.

REFERRING to Part I, Section I, in all formulas that are concerned with thickness of material, t is used to represent this value if the thickness in inches is to be used. Where the thickness is to be taken in sixteenths of an inch, T is used to represent the thickness. In some instances in the old Code the failure to make this distinction was very confusing.

Par. 9 has been modified to allow the use of malleable iron for cross-pipes, headers and cross-boxes for pressures up to 200 lb. per sq.in. provided the cross-section of such parts will fall within a 7 x 7-in. rectangle (see A, B, C).

Par. 12 has been changed to indicate that cast iron may not be used for nozzles of flanges attached directly to the boiler (see D). The intent of the original Code was to the same effect, but the point was not properly brought out.

The use of cast iron for water-leg rings and door frames, in vertical fire-tube boilers, has been prohibited by a change in Par. 13 (see E).



A

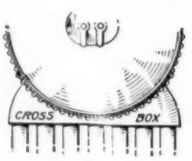
Par. 19 has been revised to show that the intermediate values for the thickness of butt straps, as given in Table I of the Code are to be determined by interpolation; strap thicknesses for plates over 1¼ in. in thickness are given. The strap thickness for plates of 1 in. thickness has been changed from ¾ to 11/16 inch.

A table giving the allowable pressures on tubes of all sizes from ½ to 5 in. diameter and with a range in thickness from 17 to 5, B.w.g., is given in connection with Par. 21. The pressures given in this table do not materially change the pressures allowed for tubes from 3 in. to 4 in. diameter in the original Code; in fact, the pressures permitted have been increased slightly for commercial sizes within this range of diameters. Radical changes in the requirements for the smaller-sized tubes have been made by the revision. In the case of tubes for fire-tube boilers, as given in Par. 22, the minimum diameter to which the table applies is made 1 in., instead of starting at zero. The last part of this paragraph has been changed so that a definite increase in pressure is allowed for each gage increase in tube thickness. The old Code allowed an unlimited increase in pressure, above 175 lb. for one gage thickness over the gages specified in the table given in this paragraph.

B

The copper content specified for firebox steel in Par. 25 has been eliminated.

The range in tensile strength for firebox steel has been changed from 8000 to 10,000 lb., as given by Par. 28. A new part, Section *b*, has been added to this paragraph, which requires a minimum elongation of 24 per cent. for material of 11/16 in. thickness or less. From the wording of Section *b* of Par. 28, it appears that the modification for the elongation for thicker plates as expressed in Par. 29, should be considered in applying Section *b* of Par. 28. However, the wording of Par. 29 appears to make the modification apply only to Section *a*, of Par. 28.

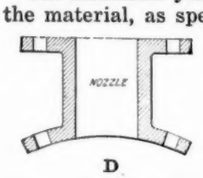


C

In Par. 30, a definite location from which the test specimens are to be taken is given. The tension-test specimen A (see F) to be taken from the bottom of the plate and in the direction of the longitudinal axis of the ingot; except that for plates that are to be used so that the transverse axis of the plate is to lie in the circumference of the shell, this test specimen *B* shall be cut at right angles to the axis of the ingot. The bend-test specimen *C* is specified to be cut transversely from the middle of the top of the plate. Specifying this location and direction for the bend-test specimen seems to be entirely proper, if the prescribed test is one that all portions of the plate should meet. It is practically certain that if the specified sample meets the requirements, all other portions of the plate will be up to the required standard.

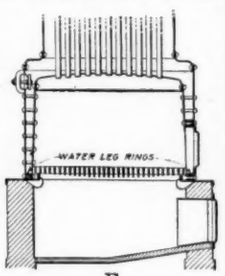
The quench-bend test, as previously specified in Section *b* of Par. 30, has been eliminated in the new Code.

The minimum yield point of 0.6 of the tensile strength of the material, as specified in the second line of the table in Pars. 123 and 141, has been changed to 0.5 of the tensile strength of the material.



D

The manganese content for tube material, as specified in Par. 165, has been changed from a range of 0.30 to 0.50 per cent., to from 0.30 to 0.60 per cent. The flange test, as given in Par. 167, has been materially changed. The old Code made a uniform requirement calling for a flange of ⅜-in. width to be turned on tubes of all sizes and thickness. The new Code requires the flange test only for tubes 6 in. or less in diameter, and where the thickness is less than 10 per cent. of the outside diameter, and provided this thickness does not exceed No. 6 B.w.g. The width of the flange to be turned is also limited to 10 per cent. of the outside diameter of the tube, between the limits of ⅛ and ½ inch.

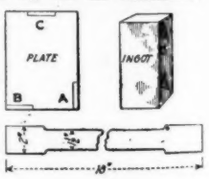


E

For the hydrostatic test on tubes required by Par. 169, a limit of 16,000 lb. per sq.in. for the fiber stress produced by the prescribed test has been exceeded by the Where this limit specified, a test pressure formula is given to determine what the test pressure shall be.

The requirements for workmanship, as specified in Par. 174, have been changed so as to make a distinction between the requirements for contour for tubes 3½ in. in diameter and less, and those of larger size.

The rule for back pitch, as given in Par. 182, has been changed and is now in a more easily understood form than previously.

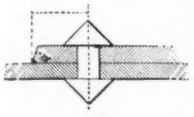


F

Par. 183, which deals with the amount of lap that is to be left on longitudinal seams, now specifies a maximum as well as a minimum limit for this dimension. The points between which the lap is to be measured are also indicated, and a limit for the angle of the bevel on the calking edge has been designated (see G).

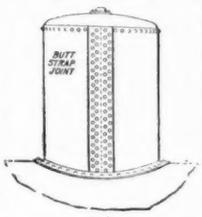
The addition of the words, "that required for," in the third line of Par. 184 *a*, has removed an inconsistency which existed in the previous Code. The requirements as now stated for the strength of girth seams in this paragraph are based on the required strength of the longitudinal

seams instead of on their actual strength. By an addition made to Par. 186, the use of autogenous welds is permitted, provided such welds are not subject to stress and the safety of the structure does not depend on the strength of the weld.


G

An addition to Par. 187 indicates that the first portion of this paragraph, which specifies that butt-strap construction is required on the shells of drums over certain diameters, does not apply to the portion of the shell which is staybolted to the firebox, as in the case of the vertical fire-tube type of boiler.

By the addition of Section *c* to Par. 192, a requirement for the relation between the strength of the longitudinal and circumferential ligaments between the tube holes in a drum where the tubes enter the shell, is given. These requirements are the same as those given in Par. 184 in reference to the required strength of longitudinal and circumferential seams. The treatment of the strength of diagonal ligaments between tube holes in the shell of a drum has been changed; a diagram has been substituted for one of the formulas previously used in this paragraph.



H

The wording of the first part of Par. 194, relative to domes, has been revised to definitely indicate that the longitudinal joint on a dome 24 in. or over in diameter must be of the butt-strap construction. The previous wording of this paragraph appeared to make the requirement for butt-strap construction hinge on the requirement for a pressure in excess of 100 pounds (see H).

An addition has also been made to this paragraph relative to domes, which specifies limits for the radius used on the flange of the dome.

In Par. 199 a new value for *c* has been added. This value is 150 and applies to stays screwed through the sheet or to taper-fit stays, provided they have heads not less than 1.3 times the diameter of the stays.

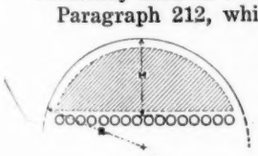
I

In Par. 200 a change has been made which removes the necessity for drilling the ends of stay-bolts as specified in that paragraph, provided the length of the bolts is in excess of 8 inches (see I).

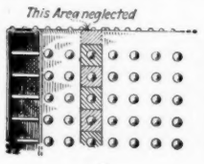
The rules in Par. 201, in regard to the staying of boiler heads, have been elaborated and made more definite.

Paragraph 203 has been made much more explicit and is now arranged to cover the spacing of every kind of brace commonly used on the flat surface of a boiler head.

Paragraph 212, which was a two-line paragraph in the former edition of the Code, is now over a page in length. This paragraph formerly dealt only with the question of cylindrical surfaces which required staying. In the present Code the strength of constructions similar to the outer furnace sheets of a vertical fire-tube boiler is treated, and also the strength of the wrapper sheet of a locomotive-type boiler. Both of these subjects are new. Following the above, the question of the spacing of the stays on a cylindrical surface is considered. Instead of requiring such spacing to be the same as for flat surfaces, as was the case in the former Code, an extra allowance is given for the spacing of stays on cylindrical surface. The requirements for the area on the segment of a head to be stayed, as specified in Par. 214, have been changed. In the former Code, the surface 2 in. from the tubes and 3 in. from the shell was deducted from the total area of the head to find the area to be stayed. The distance from the shell, used to find the area to be deducted under the new rules, may vary with the radius of the flange, the thickness of the head and the allowable pressure. The area that may be deducted under the new rules will generally be greater than was permitted under the former rules. The change in this paragraph, 214, has also been made to replace the first portion of former Par. 215, relating to the heads of water-tube boilers (see J).


J

K



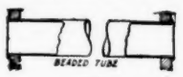
L

The rule specifying the distance apart that tubes may be spaced in a fire-tube boiler without requiring the application of stays as expressed in Par. 216, has been changed; the intent of the new wording, however, appears to be the same as before.

The formula given in Par. 217, for determining the area to be stayed on the segment of a head, has been rearranged so as to comply with the changes made in Par. 214.

An addition has been made to Par. 218 which makes the minimum distance, in the clear, between through braces placed below the tubes in the horizontal-tubular type of boiler, 10 in. This should be a welcome change to the boiler inspector and to the boiler cleaner (see K).

Paragraph 220, which treats of the subject of computing the stresses in stays, has been materially lengthened. Conditions which arise in practice, the treatment of which may be confusing to the designer and the boiler inspector, are fully explained (see L).



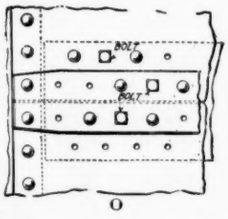
M

Two lines have been added to Table V, which gives the maximum allowable stress for stays and stay-bolts. One of these additions indicates that for hollow stay-bolts of less than 20 diameters in length, an addition in the allowable stress of 500 lb. per sq.in. is permitted over that allowed for similar bolts that are solid or of the flexible type. The other addition to this table provides for the allowable stress for steel through stays that are over 1½ in. in diameter

To determine the design of braces and brace conditions, Par. 223 has been divided into eight divisions, and the whole subject appears to have been covered. The former wording of this paragraph was not clear, and the changes made will no doubt be welcomed by the designer and the inspector.

N

A limit for a minimum vertical distance between the rows of tubes, where a staggered arrangement is used, has been given for use in applying the requirements of Par. 234. The subject of plain cylindrical furnaces, as treated in Par. 239, has been changed considerably. The formulas used have remained unchanged. Unstayed furnaces from 12 to 18 in. in diameter have been provided for; if not over 4½ diameters in length, they are considered as furnaces, if of greater length they are considered as flues. It is now arranged that for furnaces of more than 18 in. up to and including 38 in. in diameter, if over six diameters in length, the length is to be assumed as being of six diameters for the purpose of calculating the maximum allowable safe working pressure. This removes a serious criticism of the former rules in regard to long furnaces. It has been shown by experiment that six diameters is the critical length, and that beyond this point length is not a factor to be considered in determining the strength of a furnace.



O

Paragraph 245 has been changed with regard to the pressure that is to be allowed on malleable-iron headers. This change was evidently made to obtain agreement with the change that was made in Par. 9.

The test requirements for malleable-iron headers have been inserted in Par. 246; this paragraph has also been arranged to cover the subject matter of old Par. 247.

A new Par. 247 has been inserted, which provides for the testing to destruction of a boiler or boiler parts where it is impossible to calculate the strength with a reasonable degree of certainty. This is an important provision and should prove useful.

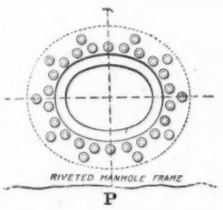
The wording of Par. 250 has been changed so as to

require the beading of both ends of the tubes in fire-tube boilers (see M).

Paragraph 251 has been modified to permit the welding of tube ends in water-tube boilers.

Fig. 20, on page 71, has been added. This illustrates the form and dimensions of acceptable rivet heads (see N).

It is specified in Par. 254, that after the rivet holes have been drilled and the burrs removed, the reassembling of the parts shall be accomplished by the use of barrel pins and tack bolts.



P

A requirement that has been added to Par. 256 makes it necessary to drive a rivet each side of each tack bolt used before the tack bolt may be removed (see O).

A specification of the angle to which the calking edges of plates, butt straps and heads are to be beveled, is inserted in Par. 257. A similar requirement relating to the calking edges at the longitudinal seams has already been mentioned in connection with the changes made in Par. 183.

An addition made to Par. 258 makes it necessary to reinforce a handhole opening where the longest dimension of such opening is more than 6 inches.

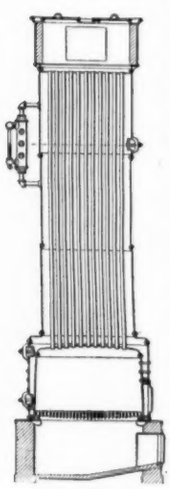
The treatment of the requirements for reinforcing manhole openings, as given in Pars. 260 and 261, has been changed. Par. 260 now indicates what the requirements are that must be met as regards the reinforcing rings, and Par. 261 indicates what the requirements are that must be met in regard to the strength of rivets (see P).

The wording of Par. 266, which deals with the requirements for the application of handhole openings has been changed. The requirements given in the old Code do not apply to boilers of 24 in. diameter or less; two openings are specified as a minimum for these small boilers (see Q).

A change in Par. 268 requires that for all boilers to be operated at pressures of over 100 lb., any outlet over 3-in. pipe size must be arranged with a flanged connection.

Safety Valves

The limit for the size of safety valves where one may be used alone, as specified in Par. 269, has been changed from 3-in. diameter to a limit expressed in relieving capacity, this limit being 2000 lb. of steam per hour. The limit for the maximum lift of safety valves, as previously specified in Par. 272, has been removed. Any lift up to one that will give a discharge up to the full discharge capacity of the opening at the base may be used, provided the valve is so constructed as to open gradually, so as to not lift the water in the boiler, and further provided that no detrimental shocks are produced through the operation of the valve. The limits for diameters of safety valves, as previously provided in this paragraph, have also been removed.


Q

The requirements as regards the markings to be placed on the body of a safety valve, as covered by Par. 273 have been considerably changed.

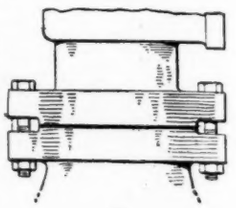
The safety-valve relieving capacity that must be supplied for a boiler, as required by Par. 274, has been changed as regards boilers operating at pressures of 100 lb. or less. For such boilers a basis of 3 lb. of steam per square foot of boiler-heating surface per hour, is used.

Requirements for discharge pipes used in connection with safety valves have been added to Par. 279.

The requirements for the lifting gear to be supplied with safety valves, as given in Par. 282, have been modified. Without steam on the valve, the lifting gear must be capable of lifting the valve $\frac{1}{4}$ in. from its seat instead of one-tenth of the valve diameter, as previously required.

A requirement has been inserted in Par. 283, that the seat of a safety valve must be fastened to the body of the valve so as to prevent the seat lifting with the valve. It is specified in Par. 284 that a safety valve and its spring must be so constructed that the valve may lift from its seat one-tenth of the diameter of the valve seat before there is any interference.

A change in Par. 286 permits the use of flat-faced flanges for safety valves for pressures as high as 250 lb. Raised faces must be used on the flanges of safety valves for pressures over 250 pounds (see R).


R

A change in Par. 288 requires that at least 75 per cent. of the total safety-valve relieving capacity that must be supplied for a boiler shall be placed directly on the boiler, when the relieving capacity of safety valves that are attached to the superheater are to be considered in connection with the total relieving capacity required. An addition to Par. 290 provides for the attachment of internal collecting pipes or splash plates for safety-valve outlets; certain restrictions in regard to the design of such devices are given.

Water and Steam Gages

An addition to Par. 291 specifies how the lowest permissible water level for the various types of boilers may be determined.

The absolute restrictions as to the use of automatic water gages, given in Par. 292 of the previous Code, have been removed. Such devices are permitted, if constructed in accord with specifications for automatic water gages, given in the appendix of the Code.

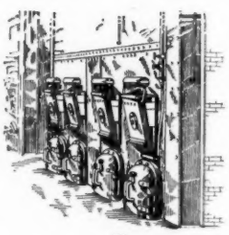
S

A provision has been added to Par. 296, to permit the proper installation of valves in steam-gage lines where the gages are located at a distance from the boilers.

Par. 299 has been increased materially. The added matter treats of the use of cast-iron and steel fittings and clears up much of the ambiguity that existed in the previous edition of the Code in regard to the this subject.

Blowoff requirements, as specified in Par. 311, have been changed so that the requirements specified for stationary boilers do not apply to traction or portable boilers.

Par. 314 has been changed by removing the requirements in regard to the use of globe valves on feed lines and placing them in Par. 317 (see S).


T

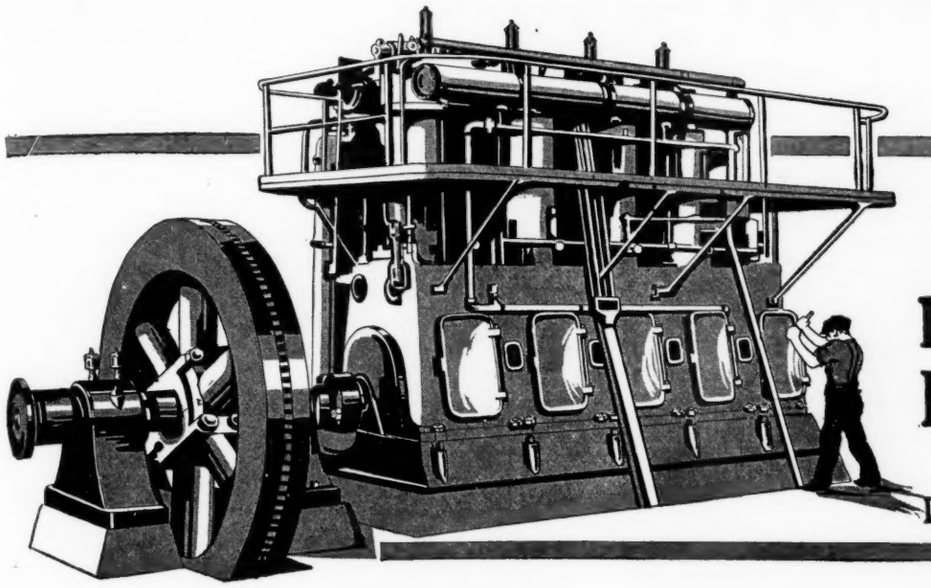
A method of attaching the supporting brackets on traction or portable boilers that differs from similar requirements for boilers of other types is given in Par. 325.

The requirement for inward opening doors, or that the doors must be supplied with substantial latching devices, in the case of water-tube boilers, is now made to apply to stoker-fired boilers of this type as well as to those fired by hand, according to changes that have been made in Par. 328 (see T).

The stamping of boilers, as provided for in Par. 332, has been materially changed. The new paragraph on this subject takes up a space of practically two pages. It should be read carefully by the inspector and manufacturer.

(Revisions in Part I, Section II, Heating and Hot-Water-Supply Boilers; Part II, Existing Installations, and the Appendix will be given in the next issue of POWER, Feb. 18.)

The new giant tri-plane type flying machine nearly completed by Giovanni Caproni, to be driven by Liberty motors, develops 21,000 hp. It is of six-ton capacity and built to carry 29 passengers. The plane will be luxuriously finished. The interior will be modeled after a limousine, with upholstered seats and glass-inclosed passenger compartment. It will be heated by electricity and the motors will be equipped with muffler.



Talks on DIESEL Engines

by L. H. Morrison

VI—At this meeting the talk turns to piston rings and piston construction. Egan explains the reason for scoring of cylinders and sticking of pistons.

ON THURSDAY NIGHT, when the men gathered for their regular hour of discussion, they found Egan waiting. Kelly was still engaged on his job of erecting the second-hand Diesels, and the importance he inwardly felt was reflected to some extent in his manner.

"Chief," he inquired as he rolled a cigarette, "how bad can a piston be scored before it's got to be replaced?"

J. R. smiled as he asked Kelly the reason for the question.

"Well, I've found the pistons on those Diesels in pretty bad shape. They are cut right above the pins. I've measured them and they're about a thirty-second inch out of round. What I want to know is—does that mean new pistons?"

"Kelly," said Egan, "when a piston is as bad as that, you may as well give up all hope of good results until you get a new piston. There seems to be a good bit of haziness over the allowable piston wear. Some engineers think that new rings will stop all compression leaks, no matter how badly the piston is scored.

"I've interested myself in this question, and I've never found any piston delivering the goods when the clearance between cylinder and piston was over one-hundredth of an inch. I might even go stronger and say that seven-thousandths of an inch is the maximum clearance that should be allowed."

"Don't you think rings will help?" asked Woods.

"Why, yes, rings will help in any case. If we had no rings, we would lose our compression even if we had only one-thousandth clearance. The point I am trying to make is that an engineer shouldn't expect new rings to remedy a worn piston."

In next article the chief explains the causes of piston distortion and fracture and methods of overcoming such troubles

"I've been seeing a lot of advertising of the two-piece ring," continued Woods. "Will that work in a Diesel?"

"I've no doubt that a two-piece ring is leak-proof in a gasoline engine, where the compression is below 100 lb. per sq.in., but it won't stand up in a Diesel. You must remember that here our compression is around 550 lb., and the two pieces of the ring will wedge together. This isn't theory—I've proved it to my own satisfaction by making up a set and trying them out."

"That's funny," exclaimed Kelly. "In those Americans I'm manhandling, the grooves are wide and take two rings per groove."

"Probably some bright engineer's experiment," J. R. answered drily. "But," he continued, "I'd suggest you measure the width of the groove and the width of the

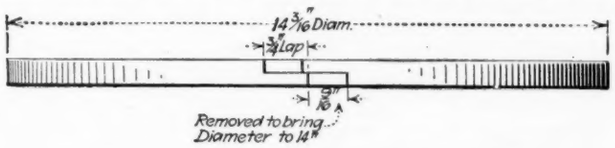


FIG. 1. FORM OF JOINT IN PISTON RING

two rings. You'll find that the groove has worn considerably wider than the rings. This play of rings in the groove allows the charge to blow past, and the wear is excessive with two rings per groove."

"Do you think a ring should be turned up eccentric before cutting?" asked Woods.

"Such a ring is designed correctly and from a theoretical standpoint is better than any other kind. However, in practice, there seems to be no advantage, and it is harder to make. In having our rings made where the piston is between 12 and 18 in. in diameter, I always order them $\frac{3}{16}$ in. larger in diameter than the cylinder bore. When machined up, there is then about $\frac{9}{16}$ in. to be cut out to let the piston enter the cylinder. In making the lap, our practice has always been to cut the rings as in Fig. 1, giving about $\frac{3}{4}$ in. lap, which insures a good seal at this point."

"J. R., what clearance do you allow between the groove and the sides of the ring?" inquired Kelly.

"A lot of engineers have new rings fit loose in the grooves. But I'd advise just enough clearance for a working fit—not more than a thousandth of an inch on each side. Then there won't be much chance for tar deposits. Another thing to remember is that it's poor policy to round off the edges of a new ring, for that causes rapid wear. The best plan is to smooth up the burrs, if there are any, but make the edges perfectly true. Usually the machine shop sends the rings with a fairly good finish, but even if the surface is fairly smooth, it's a good idea to go over the rings with fine emery cloth. For the smoother the rings, the longer they will last and the less lubricating oil required."

"J. R.," observed one of the men, "I noticed that one of our old engines has two pistons with four rings apiece, while the third piston has five. Why is that?"

"That engine, when it came from the factory, had four rings per piston," said Egan. "We found that a small amount of wear allowed the charge to leak by, and so we put a fifth ring on the middle piston, since the leakage was greatest around it. This was not done on the two outside cylinders because their pistons had thin walls—quite likely a case of slipped cores. You see, there is a thickening of the piston walls behind each ring groove; but the slipping of the core didn't leave enough metal for a groove. Another thing, you'll notice we added on all the pistons three oil grooves below the center of the piston. Originally, no oil grooves were used, but we found they helped the lubrication of the cylinder and reduced piston leakage.

"In regard to the number of rings," continued the chief, "both our new 500-hp. engines have six rings per piston, but I don't think six absolutely necessary. In fact, two of the pistons are short a ring apiece until we can get new ones.

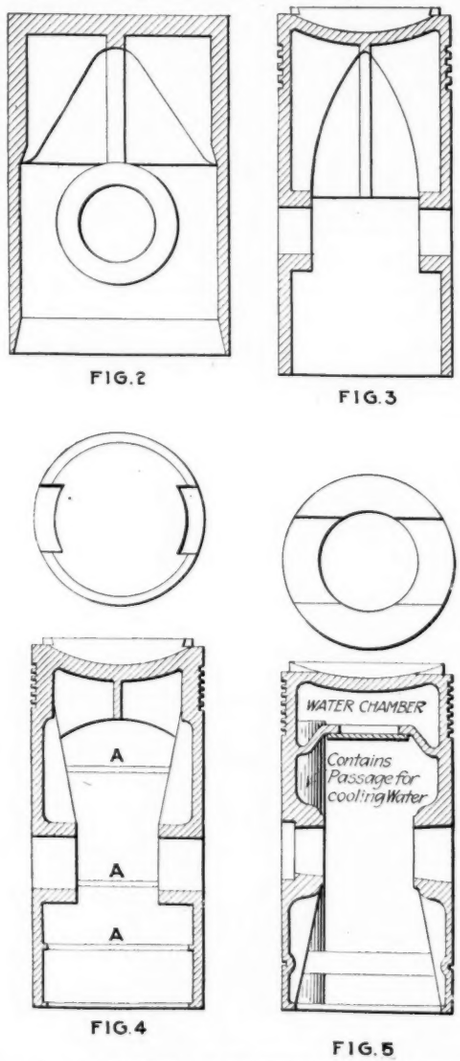
"Now, boys, when it comes to pistons, you're getting on dangerous ground. Steam engineers and critics of oil engines always harp on piston failures. But if you investigate, you'll probably find the objection based on some failure that occurred years ago, on one of the first Diesel engines. In recent years you run across few actual cases of piston seizing. When they do occur, you will usually find the trouble due to poor installation or lack of attention. This company has twenty-five Diesels of four or five makes, and I know of but one case of piston seizing. It happened right here, when Kelly first came to work for me, and it wasn't the fault of the engine, either. I had ordered a new piston and when it came it was too snug a fit; but the day engineer forced it into the cylinder by using a sledge. When the engine warmed up, of course the piston stuck."

As he finished speaking, he unfolded several sheets that he took from an inside pocket and spread them out on the table, disclosing a series of sketches like those shown in Figs. 2 to 5.

"These sketches will give you men an idea of some of the different types of pistons you may run against," the chief went on. "Fig. 2 is a section of the piston generally used on the first Diesel engines. If you are familiar with gas engines, you will agree that this is a typical gas-engine piston, the only change being the ribs to strengthen the head. This is the same piston that we have in our old American Diesel engines."

"Why did engine builders quit using this piston?" inquired Woods. "It looks simple and easy to make."

"The reason is the answer to the majority of complaints as to pistons sticking and wrecking engines. If you men will look into this matter you will see that the piston walls have very thin sections. The head is well supported by the ribs and doesn't show any more cracks than does any other type. However, the heat generated in the cylinder is partly absorbed by the piston pin, and the pin expands lengthwise. The bosses supporting the pins are fairly heavy and resist any distortion. But as



FIGS. 2 TO 5. FORMS OF PISTONS FOR OIL ENGINES

the bosses join onto rather thin sections of the wall, and these thin portions have no support, the piston is bent until its cross-section has the form of an ellipse. The long diameter of the ellipse is greater than the original diameter of the piston, and both the piston and the cylinder are bound to be scored. When the piston cools off and returns to its former shape, the ends of the ellipse will appear flat."

"Well, chief, what do you do when such scoring does happen?" asked one of the others.

"Just what we have done twice at this plant—pull out the piston and smooth the scored places to a good surface with emery paper.

"However," Egan continued, "ordinarily there is no excuse for this scoring. If the operator will allow the cooling water to circulate through the cylinder jacket for fifteen to twenty minutes after shutting down, the engine will give up all the contained heat to the water, and no great amount of heat will be absorbed by the pin. I want to emphasize the fact that the pin expansion occurs when the engine is shut down and not while it is running.

"In Fig. 3 the head is made concave to better withstand the expansion. Also notice that the ribs are all carried well down toward the middle of the piston, which, of course, makes the walls more rigid. While the ribs help to hold the piston to shape, their real value lies in the strength they give to the head. This is an improvement over the one in Fig. 2, but it can't be termed a modern design.

"Fig. 4 shows how the designer has practically eliminated all danger of piston distortion. The head is slightly concave and has short ribs to give additional support. The most attractive feature is the ribs *A* around the interior piston wall. These ribs give great strength to the wall, and there should be no distortion because of temperature conditions. I know that in five of our engines fitted with this type of piston we have had no trouble with pistons sticking.

"In Fig. 5 we have a piston built along similar lines. However, this one is intended to be water-cooled, and a water chamber is provided in the head, as you can see."

Difference in Water Levels in Boilers

By F. R. McLEAN*

IN CONNECTION with the differences of water levels occurring in multiple-drum boilers, which have been discussed at some length in recent issues, a brief outline of many observations and experiments made over a period of several years may be of interest.

The boilers at one station consisted of seventy-two 650-hp. three-drum boilers equipped with superheaters, and at another station there were thirty-two boilers of similar design and size but without superheaters. In both instances they were set in pairs having a common or party wall and the drums nearest the party wall were called inside drums. Then came the middle drums and adjacent to the outside walls the outside drums.

When the boilers were installed, water columns were fitted to the outside drums. Samples of water were collected from these columns and tested to regulate the blowing off. It was found after much experimenting that these samples did not represent conditions in the middle or in the inside drums. The salinity used as a measure of the concentration was found to remain uniformly low over extended intervals, whereas the salinities of the middle and inside drums would rise rapidly almost regardless of the amount of blowing off to values that were often seven or eight times the concentration shown in the outside drum.

Thousands of samples were taken from all three drums of the boilers, and the outside drum always contained water with the lowest salinity. It was proved conclusively that these variations were caused by different rates of evaporation, the outside drum adjacent to the relatively cool outside wall evaporating much less water than the middle or inside drum close to the party wall.

Internally, the middle and inside sections of the boilers —that is, the drums and tubes—would contain much more mud and scale than the outside sections. The feed-water connections were arranged to distribute equal amounts of water to each drum, but as the middle and inside evaporated more water than the outside, they pulled water steadily from the outside through the mud-drum, thus stirring up the mud and carrying it into the middle and inside sections. This emphasized the need for frequent inspection of the internal feed lines, drum-head check and stop valves to see that they were in no way obstructed. When the individual feed line to one drum was found obstructed, that section would show high concentration of salts, mud and scale. By the installation of orifices of slightly different sizes in the individual feed lines, a reasonably uniform concentration of deposits was obtained in all three drums.

Gage-glasses were installed on all three drums of a number of boilers, and readings were made under different conditions of operation. Some of the boilers were hand-fired, and many of the stoker-fired units were equipped with underfeed stokers. On a hand-fired boiler a U-tube consisting of two water columns and gage-glasses, was connected into the steam space of the outside and the inside drum to determine any differences in pressure that might exist. Under all normal conditions of operation the inside drum pressure exceeded that of the outside drum by from 1 in. to 4 in. of water. Firing under the inside drum was stopped until the fire was nearly dead on that side before the excess pressure changed over to the outside drum. These differences in pressure existed, although equalization was permitted through the superheater and safety-valve cross-over pipes. When the boiler was actively steaming, the differences in water levels were not great unless the fire became very uneven. The doors were numbered and fired alternately with the doors of the adjoining boiler.

In starting the boiler up from a cold or banked condition, alarming differences of water level were observed. For instance, with the water at half a glass in all three drums and the pressure 25 lb., the water in the outside drum would start down and the water in the inside drum start up as the pressure increased until it was below the bottom in one case and above the top in the other. This again was the result of the relatively cold outside wall and hot party wall, causing a great variation in the densities of the mixed steam and water on the two sides. The superheater was drained at all times. When the boiler cut in on the line automatically, the water levels would readjust themselves, showing only comparatively slight differences.

It was clearly demonstrated that unequal levels, unequal heat concentration and unequal accumulation of mud and scale were for the most part inherent in the boilers, owing to the setting in pairs. No appreciable difference in levels between the front and rear ends of any one drum was discovered.

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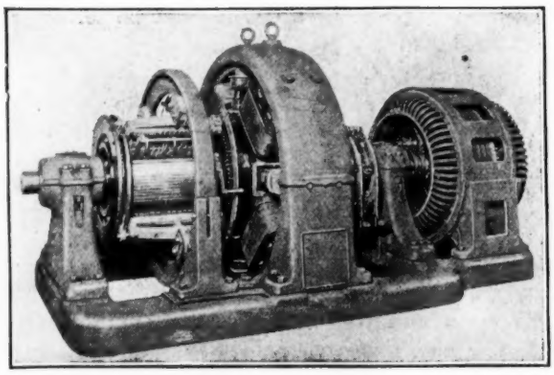


Characteristics of Carbon Brushes for Electrical Machinery

By WARREN C. KALB

Carrying capacities, contact drop, coefficient of friction, abrasiveness and hardness of carbon brushes are defined and the methods of determining those characteristics are explained

IN THE application of carbon brushes to any given service there are certain physical characteristics that must be taken into consideration. These are determined by the manufacturer of the brushes through exhaustive laboratory and service tests and are made available to the user by means of tables, curves and descriptive data. It will be interesting to discuss some of the more important of these characteristics.

Carrying capacity is the load-current density in amperes per square inch of cross-section that a brush can carry without serious heating. In determining the carrying capacity of a given grade of brush, it is necessary to consider all the factors affecting the temperature of that brush in operation. This includes, in addition to the specific resistance of the brush, its commutating properties, coefficient of friction and heat conductivity.

The carrying capacity indicates the permissible current density in the brush on a machine of average design under normal operating conditions. Higher current densities can be permitted for short periods of overload, unless the conditions affecting the brush operation are unusually severe. The following table gives some idea of the carrying capacities of the different types of carbon brushes. These will be described in a subsequent article.

Carbon-graphite	30 to 40 amp. per sq.in.
Graphite-carbon	35 to 50 amp. per sq.in.
Graphite	55 to 70 amp. per sq.in.
Electrographitic	30 to 65 amp. per sq.in.
Metal-graphite	50 to 125 amp. per sq.in. for commutators
	70 to 150 amp. per sq.in. for slip rings
Carbon-gauze	80 to 100 amp. per sq.in.
Metal-gauze	Up to 200 amp. per sq.in. on slip rings
Copper-leaf	Up to 200 amp. per sq.in. on slip rings

On motors subject to intermittent service, such as crane motors, vehicle motors and railway motors, it is possible to use a considerably higher rating than that normally given. This is because the brush has opportunity to cool off between periods of use.

When considering carrying capacity in the selection of a brush for any given service, the load-current density should be figured in the brushes at the full load on the machine and the grade selected which has a carrying capacity equal to or above the current density estimated. If the machine is to be operated for long periods at a considerable overload, it is well to make the selection as regards carrying capacity more liberal than for a machine that is to be operated at or near normal load.

The resistance at the contact between a brush and the commutator or slip ring on which it bears varies approximately in inverse ratio to the current density. In other words, the voltage drop across the brush contact is approximately uniform over the working range of current densities, and for this reason this characteristic is expressed as contact drop rather than as contact resistance. The contact drop as usually given by manufacturers of brushes is the sum of the drop across the positive and negative brushes. The drop across the contact of one brush is approximately one-half the figure given for the positive and negative.

Fig. 1 shows the general method used in determining contact drop. The brushes to be tested bear on a copper ring or short-circuited commutator *R* which is driven by an adjustable-speed motor so that the contact drop can be tested at any desired peripheral speed. These brushes are connected through an ammeter *A* to an external source of power which may be either of variable voltage or controlled by a rheostat in series with the brushes *B*. Leads from a voltmeter *V* are placed on the brushes as near their contact surface as possible, and in this way the voltage drop across the contacts of positive and negative brushes combined is determined. This is the form in which this information is usually published. If it is desired to give the contact drop of either positive or negative brush alone, one of the voltmeter leads must be placed in contact with the ring on which the brushes bear.

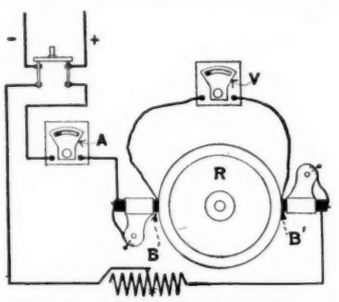


FIG. 1. METHOD OF MEASURING BRUSH CONTACT DROP

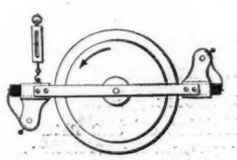


FIG. 2. METHOD OF MEASURING COEFFICIENT OF FRICTION

Contact drop has more influence than any other on the commutating properties of a brush. For this reason it is desirable that it should be as high as possible consistent with other characteristics on any brush which is to be used on commutating service except on the lower ranges of voltage. On machines with a terminal voltage of less than 100 it becomes desirable to keep the contact drop of the brush as low as the commutating characteristics of the machine will permit, otherwise the heat loss at the brush contact may become a considerable percentage of the total losses in the machine.

Most brushes used on industrial and power apparatus

of 110 volts and above will have a contact drop of 1.5 to slightly over 2 volts. Brushes for automobile-starting motors, where high torque rather than commutation is the determining factor, will have a contact drop as low as 0.2 volt. This, of course, can be secured only in a metallic or composition brush.

Brushes for electroplating generators, battery-charging generators, vehicle motors and other types of low-voltage machines require contact drop between the ranges previously mentioned. On slip-ring service high resistance at the brush face is of no advantage, and for this reason the contact drop should be kept as low as possible consistent with the other characteristics required in the brush.

The coefficient of friction is the ratio between the tangential pull exerted by the commutator or slip ring on which the brush bears and the radial pressure applied at the brush face. This characteristic determines the peripheral speed at which it is permissible to operate a brush without chattering or undue heating. It is customary among brush manufacturers in describing their grades to give the maximum peripheral speed to which each grade is adapted rather than the coefficient of friction. Information so given is more readily used in applying the brush to service than the abstract figure for coefficient of friction.

In measuring coefficient of friction a machine is used similar to that on which contact-drop tests are made. In fact, the same apparatus is frequently used for both tests. In making the coefficient of friction tests, however, it is necessary that the brush-holders should be supported on a movable yoke which is capable of oscillation about the same axis as that of the slip ring or commutator on which the brushes bear. A spring balance attached to this yoke at any point and held in a position at right angles to it will give the tangential pull at the point of attachment due to the friction of the brushes on the ring as indicated in Fig. 2. Multiplying this figure by the ratio of the radius arm at the point of attaching the spring balance to the radius of the ring will give the tangential pull at the brush faces. This figure divided by the total pressure applied to all the brushes bearing on the ring gives the coefficient of friction.

Another type of apparatus has been used for both contact drop and coefficient of friction test in which the brushes, instead of bearing on the periphery of a ring, bear on the flat surface of a disk. This type possesses certain advantages as well as disadvantages over the ring type, one of the principal advantages being the accuracy with which the surface can be ground, insuring uniform condition at the start of every test.

Brush manufacturers are at times unwilling to admit that any grades of their products possess abrasive properties. This is due to a prejudice that has grown up against abrasive brushes and the belief that the possession of any abrasive property whatever is likely to result in excessive commutator wear. This is an unfortunate condition, as there are very often circumstances where the possession of a moderate degree of abrasiveness is a decided advantage in a brush. This is particularly true on commutators, the mica of which has not been undercut, making it necessary for the brush to cut away the mica as the surface of the copper is burned down under severe operating conditions.

Where the mica of the commutator is undercut, it is not necessary to have any abrasive property in the brush, except under very severe conditions of operation, and even then only enough abrasive or polishing action is required to overcome whatever burning occurs on the commutator surface and keep it in a nicely polished condition.

Brushes are manufactured which are absolutely non-abrasive as near as such a condition can exist. Other grades are manufactured which possess a polishing action and still others which possess various degrees of abrasive action. A few grades are made with such a degree of abrasiveness as to result in serious cutting action on the commutator. These grades are not to be recommended except under the most extreme conditions. Unfortunately, there is no reliable test for this most important brush characteristic, nor is there any unit by which it may be described. For this reason the best that a manufacturer can do is to describe this characteristic of his brushes in general terms. Hardness is a term that is frequently confused with abrasiveness, but as a matter of fact is an entirely different characteristic. It relates to the compactness of the mass of the brush as a whole, whereas abrasiveness relates to the cutting action given a brush due to the presence of more or less gritty particles in the brush composition.

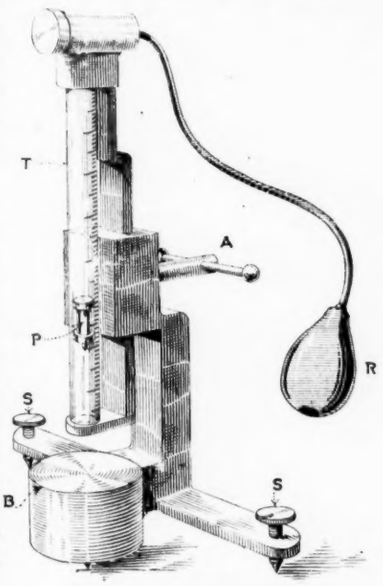


FIG. 3. SCLEROSCOPE

Hardness has less influence on the operation of brushes than is generally supposed, but where other conditions are equal the harder brush will usually have longer life. On the other hand, the softer brush will be quieter where there is a tendency for vibration or chattering. While a very hard brush may possess absolutely no abrasive property, the harder of two grades will usually polish a commutator or ring better than the softer, provided the abrasive characteristics of both grades are similar.

It is customary to define the hardness of a brush by means of the scleroscope test. This is a small instrument in which a steel weight is allowed to fall from a constant height upon the article whose hardness is to be measured. The rebound along a graduated scale is recorded as a measure of the hardness of the article. The following table gives a comparison between the scleroscope reading and the degree of hardness as relating to brush material:

Scleroscope	Degree
0 to 15	Very soft
16 to 30	Soft
31 to 45	Medium
46 to 60	Hard
61 and over	Very hard

The scleroscope consists primarily of a glass tube *T* about 10 in. long mounted on a substantial frame and

adjustable in height by means of the lever *A* with relation to the base of the frame *B*, Fig. 3. Before making a test the heavy base plate *B* is carefully leveled by means of the adjusting screws *S*, which insures the tube *T* being vertical. A sample of the material to be tested is then placed on the base *B* and the bottom of the tube brought down firmly upon it.

Within the tube is a small loose-fitting weight or piston *P* having a diamond point. The diamond point is used to insure uniformity in shape, inasmuch as even the hardest steel would gradually change shape under continued use and affect the reading of the instrument. By means of the bulb *R* this piston is drawn to the top of the tube, where it is held by a latch until released by another pressure of the bulb. When released, it drops freely upon the sample being tested and rebounds, the height of the rebound depending on the hardness of the material on which it is dropped. At the back of the tube is a graduated scale by means of which the rebound is measured, and the reading of this is recorded as the scleroscope indication of hardness.

This reading does not represent any definite unit, but is merely an arbitrary scale. It is a fairly accurate indication of the relative hardness of materials of like nature that cannot be used to judge the relative hardness of dissimilar materials. The figures given in the table are intended to convey to the man experienced with brushes some idea of what the scleroscope readings indicate. That is, a brush that he would class as being soft would probably fall within the range of 16 to 30 on scleroscope readings, a brush which he would class as medium in the range 30 to 45, one that is hard in the range 46 to 60, and so on. Specific resistance, mechanical strength, and density, both real and apparent, are other characteristics which are studied by the brush manufacturer, but which are of minor importance to the user and will not be discussed at this point.

(*The next article will discuss the composition and construction of the various types of brushes and their application.*)

Lend to the End!

American patriotism fights for America in peace as well as in war. We talk America, think America and frequently dream America. Our armies fought and won the war in France. We fought on this side with our labors and dollars. Now we are to fight again—in the new day of peace, to insure permanent peace and prosperity. Again it is a question of patriotism, with the same munition—dollars.

Secretary of the Treasury Carter Glass estimates the probable amount of the new Victory Loan at $5,000,000,000. Victory Bonds will be offered for popular subscription within a few weeks. They will offer to all of us the last time in our lifetime, probably, to strike decisively for the United States in the fight to uplift a world to our democratic standards.

Only the shirker will seriously ask why another loan is necessary. The answer is plain. America started out to finish a big job—the biggest, undoubtedly, she or any other nation ever attempted to accomplish. The armistice brought a cessation of hostilities, but it did not pay war's bills, the billions required to provision, clothe and care for a huge army.

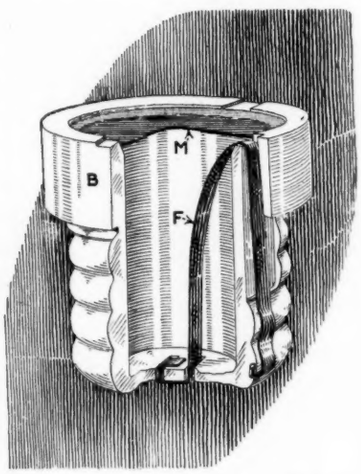
We still have an army of one million men in France to be fed and otherwise maintained for a considerable period of time. Prior to this war such an army would have staggered the national imagination, but world emergencies dictate that we must maintain it at present. We assure ourselves of emergency capital through support of the Victory Loan. This forthcoming war bond issue is our method of finishing up the world's biggest job. Americans never quit; they finish strong, spurred by the patriotism peculiar to all of us.

Citizens of a republic which sent two million men oversea to fight, want to bring them back as soon as possible. They want to give a chance to men who left their work to develop their resources again in a debt-free country. Nobody will oppose the idea of teaching the maimed self-supporting trades. We all want the wounded to receive the best possible care until the last man leaves an army hospital.

Accomplishing these things is constructive fighting, in which patriotic Americans everywhere can participate. Putting over the Victory Loan will be the finest sort of fighting with which to finish the "biggest job."

Refillable Plug Fuse

Most readers of *Power* no doubt are familiar with the various types of refillable cartridge fuses and multiple types of plug and cartridge fuses on the market, which have been described in this paper from time to time. Here is another one of the latest of the refillable-fuse family, a refillable plug fuse, manufactured by A. F. Daum, Pittsburgh, Penn. As shown in the figure, the only metal part to this fuse is the fuse metal. The metal thread, base plug and part of the cap used in the old type of nonrefillable fuse have been eliminated. There are only three parts to this fuse: A porcelain base *B;* a mica cap *M*, which is pressed into the base, but which can be removed and replaced to fill the fuse; and the fuse metal *F*. The fuse metal strip is placed in the plug as indicated in the figure, and when the fuse is screwed into the cutout socket, contact is made between the fuse metal and the socket at the side and bottom. These fuses are made in sizes from 3 to 30 amperes for 125-volt circuits, and the refillable fuse strips are put up 100 in a box, in any amperage up to 30.



SECTIONAL VIEW OF FUSE

Because of the inherent shortcomings of raw lignite as fuel, one can safely say that it will never be used to any great extent in its raw state. The fact that it contains 30 per cent. of water alone would prevent its use elsewhere than in the immediate vicinity of the mine.

Combustion and Boiler Settings—II*

By A. D. WILLIAMS

The effect produced on the combustion reactions and the circulation of the gases by the chilling due to contact with water-cooled surfaces is described.

WHEN coal or other commercial solid combustible is burned directly in the firebox, it is difficult and in some cases impossible to obtain a temperature around 1600 deg. C., though the theoretical combustion temperature of a good grade of coal in an athermal inclosure is about 2050 deg. C. This temperature limitation arises from the fact that it is practically

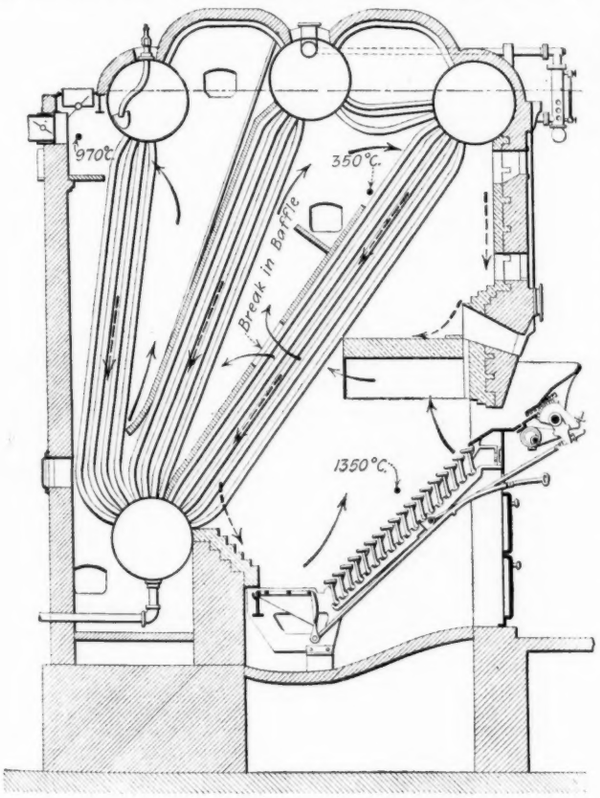


FIG. 1. FLOW OF GASES IN BOILER WITH BROKEN BAFFLE

impossible to force sufficient air for complete combustion through the incandescent bed of fuel; in other words, the bed of burning fuel acts as a producer of combustible gases which in turn must be burned by an additional air supply.

A very interesting series of tests on "Combustion in the Fuel Bed of Hand-Fired Furnaces" (Bureau of Mines, Technical Paper 137) has been made by Kreisinger, Ovitz and Augustine. One of the features of this paper that attracted the writer's attention was the fact that the mass of air per unit of combustible as computed from the analysis of the gases in the upper layers of the fuel bed was, in all cases, less than the mass of air per unit of combustible as measured by an orifice meter introduced into the ashpit. The quantity of air forced into the ashpit was also less than the theoretical air supply required for the fuel.

In endeavoring to obtain an explanation of this difference, it was found that the computed combustion temperatures derived from the heat capacity of the gases in the fuel bed agreed very closely with the observed temperatures. This would appear to indicate that a part of the air supply, instead of passing up through the fuel, passed up the walls of the firebox. Another thing the writer recalled that pointed to such a conclusion was that he had noticed on several occasions that a fire seemed to burn faster close to the wall than it did in the center of the grate and that he had frequently noticed clinkers along the walls and fused to them when the central portion of the fuel bed was free from clinkers. This last would seem to indicate a sort of air-blast or oxidizing-zone effect close to the walls, strong enough to solidify the viscous ashes.

Another indication of the possibility of the air passing up between the wall and the fuel bed lies in the fact that the CO_2 curve in a number of the tests had two peaks—one a high peak with low CO, then a steady decrease in CO_2 with an increase in CO, this valley being followed by an increase in CO_2 (and a decrease in CO) to a low peak, then another drop in CO_2. The last drop in CO_2 showed in only a few cases, and may be an error, as it is very slight.

The following tabulation of the results with a 12-inch fuel bed summarizes the combustion results obtained:

	Pittsburgh Coal 7 Tests			Anthracite Coal 7 Tests			Coke 7 Tests		
	Av.	Min.	Max.	Av.	Min.	Max.	Av.	Min.	Max.
Carbon in ash, per cent. of total carbon	7.98	3.95	17.90	10.76	2.96	24.80	7.32	3.80	9.55
Carbon burned, per cent. of total carbon	92.02	82.10	96.05	89.24	75.20	97.04	92.68	90.45	96.20
Per cent. of carbon burned to CO_2	17.00	11.00	25.00	16.95	7.90	31.50	22.00	14.90	29.00
Per cent. of carbon burned to CO	76.00	65.00	85.00	82.53	68.00	91.50	77.70	71.00	84.90
Per cent. of carbon burned to CH_4, etc	4.00	1.00	10.00	0.52	0.30	1.00	0.30	0.10	0.60
Pressure in ash pit, inches of water	....	0.13	1.33	....	0.20	2.36	....	0.05	1.67
Pounds of coal per sq.ft., per hour	....	21.00	131.00	....	20.00	99.50	....	15.00	118.60
Pounds of air per pound of fuel	....	4.10	6.10	....	5.70	7.50	....	6.10	7.30
Pounds of air per pound of combustible	....	5.00	8.20	....	7.30	10.70	....	8.10	10.60
Pounds of air per pound of combustible from gases	....	5.20	7.20	....	5.90	6.60	....	6.60	7.60

The weight of air required to burn one pound of combustible will vary from 11.5 to 15 lb. and have a volume at ordinary temperatures of from 144 to 187 cu.ft., but the amount of air that can be forced up through the fuel bed is much less. The specific gravity of coal will average about 1.20, and a cubic foot of coal as fired will weigh from 40 to 50 lb. From this it will be seen that the volume of the voids will be between 33 and 45 per cent. of the mass and this will give the proportion of the fuel-bed area through which the air must be forced. The temperature of the fuel bed and of the gases leaving it will be about 1400 deg. C., and the gases will have an impressed velocity. The limit of ashpit pressure is reached when the ascending volume of

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air forced through the fuel is sufficient to keep it floating. Such an intense draft pressure, however, would tend to carry unburnt fuel away from the grate.

When the burning gases leave the fuel bed, they have an ascensional velocity due to their temperature alone of between 30 and 80 ft. per sec. and are at least 1000 deg. C. hotter than the heating surface of the boiler. As a result the ascending stream of hot gas will be much smaller than the area of the pass and the firebox, the remainder of this area being occupied by cooler eddies of gases chilled by their contact with the heating surface of the boiler and the walls of the settings.

An interesting illustration of the way gas may flow through a setting was shown on page 709 of *Power*, Nov. 17, 1914. Mr. Smith, however, has the arrows indicating the course of the gases pointing wrong. The corrected figure is shown in Fig. 1. The hot gases from the fire rise straight up to the coking arch. Below this arch they are forced to flow horizontally to the end of

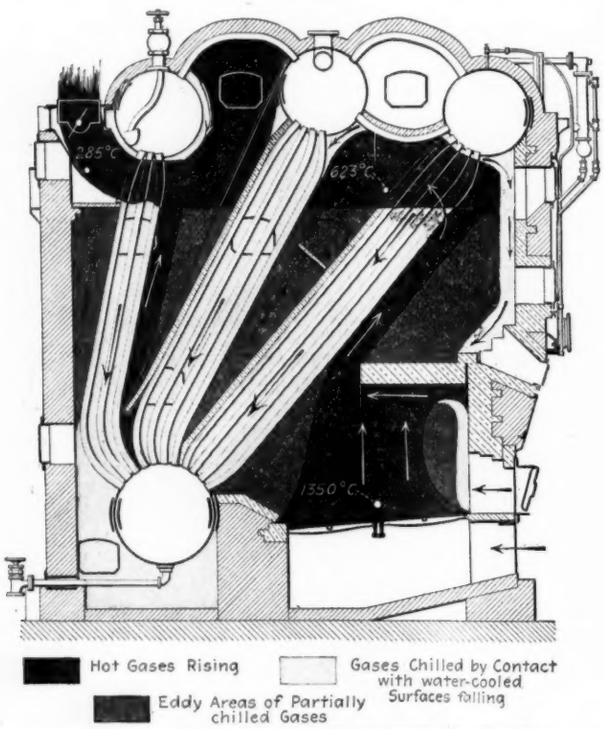


FIG. 2. FLOW OF GASES IN BOILER WITH TIGHT BAFFLES

the arch, where their velocity carries them through the bank of tubes and the hole in the baffle. In fact, it is probable that the failure of the baffle at this point was due to the continual impinging upon it of the hot gases. The current of chilled gas flowing down around the tubes of the boiler would also tend to force the hot gases flowing out from below the arch against the baffle. After passing through the break in the baffle, a portion of the hot gases will tend to rise into the upper portion of the first and second passes, while the remainder will be carried down by the current of cooler gases flowing down the second bank of tubes and will pass under the second baffle and then will immediately rise to the outlet, passing up the space between the second baffle and the third bank of tubes, then crossing the tube bank near the top, under the rear drum.

The explanation of this action is very simple. Anyone who has sat by a window on a cold day knows that the air chilled by contact with the window drops to the floor, and that the velocity of the air current is appreciable, although the difference in temperature between the inside of the room and the outside of the building is comparatively small, say from 20 to 40 deg. C. The same phenomenon, except that the current of air rises, may be witnessed in the vicinity of any radiator in a steam-heated building. The hot-air furnace installed in many homes depends upon convection currents for its action. If currents can be established at such low temperature heads, similar currents will certainly be established where temperature differences of several hundreds of degrees exist.

A phenomenon similar to the deflection of the current of heated gases flowing through the broken baffle by cooler downward currents can be set up by using an electric fan to break up and distribute the current of hot air rising from a radiator. The mere fact that a certain amount of gas is being drawn off at one point of the setting and a corresponding quantity of gas or air admitted at another part of the setting will not affect the local convection currents any more than the drawing off and admission of air into a room affects the current of cold air at the windows and of the heated air at the radiators.

Gases Do Not Flow Uniformly in Passages

Unfortunately, we have all been hypnotized by the idea that any current of gas passing through a series of inclosures sweeps uniformly through the full cross-section of all the passages, entirely forgetful of the fact that in gases, by reason of their high coefficient of expansion due to temperature changes, great variations of density occur. At a temperature of 1638 deg. C. a cubic meter of air weighs 0.171 kg., while at 0 deg. C. the same volume of air will weigh 1.293 kg., or 7.5 times as much. One thing that has tended to obscure the great difference in density that occurs in gases is that most engineering works consider only the weight of gases passing through a boiler, disregarding the fact that a unit weight of gas in the firebox will occupy approximately three times the volume it does when it reaches the smoke-flue connection. The hottest gases will tend to float above the cooler gases. Naturally, convection currents and conduction will tend to equalize the extreme temperature differences, if the supply of heated gases is not maintained, but equalization in this manner will be comparatively slow.

Fig. 2 shows the type of boiler with the broken baffle, but baffled according to the builder's catalog. The heated gases rising from the fuel bed impinge upon the arch where the direction of flow changes to horizontal. These gases when they reach the end of the arch will have a certain velocity of flow which will carry them beyond the end of the arch, possibly a portion of them into and through the first bank of tubes, before they start to rise again. The upper part of the first and second passes acts as an inverted pocket into which the hottest gases flow, the section under the front drum being much hotter than that under the second drum. The tube banks act as refrigerating surface for the gases and heating surface for the water.

The current of hot gases in front of the first bank of tubes is at least 700 deg. C. hotter than the tubes.

Their ascensional velocity, due to temperature, is sufficient to carry them the height of the setting in a small fraction of a second. A part of the gases will be chilled below the ignition temperature and below the temperature which would permit them to float over the top of the first baffle. These gases will circulate down in the spaces between the tubes, depositing soot on them, until they reach the back of the firebox, where they will absorb heat and tend to rise again.

Dissociation of CO Deposits Soot

The gases in the top of the second pass will have a temperature in excess of 600 deg. C., which is about 350 deg. C. hotter than the second bank of tubes, a temperature sufficiently low to permit 75 per cent. of the CO present to dissociate into CO_2, with an accompanying deposit of soot. The refrigerating surface of the second bank of tubes will chill these gases still further so that they will tend to drop into the lower part of the setting where a portion of them will pass under the second baffle. This portion of the gases will be hot enough to float up to the top of the third pass after mixing with some of the chilled gases that have flowed down the third bank of tubes. Some of the gas will be carried downward by the cooling action of the third bank of tubes, but the temperature difference between the water-cooled refrigerating surface and the gases is not very great at this point and the hottest portion of these gases will tend to rise farther into the smoke flue.

A number of attempts have been made to distribute the draft loss between the ashpit and the stack damper on a percentage basis between the different passes. All of these apparently are based upon the static pressure. In the boiler shown in Fig. 2 there are three vertical columns of gases. These columns exert a pressure against the top of the setting proportional to their vertical height and their average temperature, in the same manner as the gases in a chimney. As the gases in the first pass are lighter than those in the second pass they exert more pressure and therefore tend to force the gases in the second pass down and under the second baffle. In the third pass this uplift tends to accelerate the movement of the gases to the smoke flue. The greater the height of the setting, the greater the upward pressure. These pressures will naturally affect the reading of any draft gage attached to the boiler. The dynamic pressure due to velocity of flow may have an additive or subtractive effect on the reading of the draft gage, depending upon the location of the connections to the setting.

In connection with baffles designed, ostensibly, to increase the velocity of flow of the off gases, the following table gives the volumes of air supply and the resulting off gases from an exceptionally good grade of coal having a very low ash content:

Air Supply, Per Cent.	Volume at 0 Deg. C. and 14.7 lb. Pressure: Air Supply in Cu.Ft. per Lb. Coal	Volume at 0 Deg. C. and 14.7 lb. Pressure: Off Gases in Cu.Ft. per Lb. Coal
100	139	145
110	153	159
120	168	174
140	195	201
150	209	215
175	244	250
200	278	284

As the composition of the coal varies, these volumes will vary. The coal consumption per hour per boiler horsepower will vary from two pounds up, and the total amount of coal burned on a grate will depend on the size of the boiler and the amount it is forced above its nominal rating. As large sizes are the most interesting, consider an 875-hp. Stirling-type boiler operated at several loads. The total volume inside the setting is about 5100 cu.ft., and about 30 per cent. of this space will be occupied by tubes, etc., so that the net volume will be about 3570 cu.ft. A boiler of this size should operate on a coal consumption of about 2.5 lb. per hp.-hr. with 20 per cent. excess air. The gases of combustion will have the following volume:

	Volume of Waste Gases Cu.Ft. per Sec.: 120 per Cent. Air Supply	Volume of Waste Gases Cu.Ft. per Sec.: 140 per Cent. Air Supply
Normal rating	106	123
150 per cent. of rating	159	185
200 per cent. of rating	212	246
300 per cent. of rating	318	369

The average temperature of the gases within the setting will be about 800 deg. C., and the average minimum and maximum gas volumes will be 417 and 1455 cu.ft., from which the average time of the gas inside the setting will be 8.56 sec. for the minimum amount of gas and 2.46 sec. for the maximum amount of gas. This gives a temperature drop of from 117 deg. to 407 deg. C. per sec. The distance from the grate to the smoke-flue outlet is about 60 ft., which gives an apparent velocity of flow ranging from 7 to 24.5 ft. per second.

Upward Pressure of Gases Against the Combustion Arch

Assuming that the combustion arch is about 6 ft. above the grate and that the gases leave the fuel at a temperature of 1400 deg. C., they will have an upward pressure against the arch slightly less than 0.10 in. of water and their velocity will be about 42 ft. per sec. At 200 per cent. of rating the volume of gases rising from the fuel bed will be about 212 cu.ft. per second, which at 1400 deg. C. will have a volume of 1300 cu.ft. The firebox of the boiler has a width of 15 ft. and the arch will be about 12 ft. deep from the front wall, giving an area of 180 sq.ft. On reaching this arch, the gases lose their vertical velocity and turn horizontally. The horizontal velocity of the gases flowing out at the end of the arch will be about 15.25 ft. per sec., and the mean velocity will be about 10.20 ft. per sec. As soon as they pass beyond the end of the arch, the hot gases will have an ascensional component due to their density of zero at the end of the arch, but increasing so that their rise will be on an arc of a parabola, unless interfered with by other forces. In the boiler setting these other forces are a current of colder gases descending among the tubes and the tubes themselves, while a portion of the gases flowing out from under the arch will penetrate the colder layer of gases and possibly reach the baffle in back of the tubes. This action will occur intermittently according as the current of hot or cold gas is stronger in its surges. Naturally, these sudden changes in the temperature of the gases at the baffle will cause cracks and ultimately failure of the baffle, as shown in Mr. Smith's article previously mentioned. When this occurs, the hot gases will pass through the break as indicated in Fig. 1.

At 226 lb. pressure, absolute, the steam temperature is 200 deg. C. The temperature of the outside of the iron tube should not exceed 220 deg. C., allowing a

liberal drop between the wet surface and the emulsion of steam and water, and assuming that the tube is free from both scale and soot. The temperature in the firebox is around 1400 deg. C., and it has been customary to assume that the curve representing the drop in temperature from the fire to the smoke-flue outlet is a regular logarithmic curve, but this curve is based on assumptions which violate the simplest principles of elementary physics. The difference of 1200 deg. C. between the hot gases and the water tube is nearly five times the temperature difference between that of the room you work in and that of liquid hydrogen, —259 deg. C. The refrigerating effect of the cold tube on the hot gases is almost comparable to dipping a red-hot bar of steel in liquid hydrogen.

The ignition temperature of the gases varies between 350 and 800 deg. C. and any portion of the unburnt gases coming in close contact with the tubes will be chilled below the ignition point. In the case of CO this may result in its decomposition, forming carbon and CO_2, which is an endothermic reaction releasing 38.8 calories per molecular volume of CO_2 formed, and depositing soot on the tubes. Another source of soot lies in the hydrocarbons. The high firebox temperature has a tendency to break these up, forming soot, CO and hydrogen. The luminosity of the flame in the firebox is due to the heating of the soot to incandescence, and unless this floating carbon is burned in a properly designed combustion chamber a considerable portion of it will be carried to and deposited on the tubes.

Combustion, like all chemical reactions, follows the law of mass action and the laws of chemical equilibrium. The velocity of the reaction is affected by the temperature of the reacting masses and the mixing of the combustibles and the comburent and by the dilution with inert gas. The velocity of the reaction increases very rapidly with the temperature. For example, a mixture of hydrogen and oxygen at 200 deg. C. will require months to combine while at 2200 deg. C. the explosion wave indicates that combination occurs in one ten-millionth of a second.

Increase of pressure increases the velocity of the reaction. This factor, while important in internal-combustion motors, does not amount to very much at the slight differences of pressure that exist in furnace fireboxes used in industrial heating. Dilution with inert gases slows down the reaction velocity by reason of the increase of the mass. The mixing has a considerable effect on the velocity of the reaction, as may be readily verified by observing the flame of a bunsen burner while altering the air supply. The slower the reaction velocity the longer the flame and the greater the distance the gases travel in burning. The temperature will be lower with a long flame than it will be with a short flame.

In a boiler it is absolutely necessary that combustion should be completed before the water-cooled surfaces are reached, as complete combustion will result in the practical elimination of the soot trouble, with a resultant increase in the efficiency of the heating surface. Most boilers and settings, however, are so designed that the incandescent gases are shot up against a refrigerating surface before combustion can be completed, the combustion arches and the baffling being so arranged that this refrigeration will be promoted, instead of combustion.

The Electrical Study Course—Three-Wire Systems from Two Generators

Describes how a three-wire system can be developed from two two-wire systems and goes on to show how the currents distribute among the wires for various conditions of loading.

IN THE preceding lesson it was shown that in a three-wire system three sources of voltage are available, two of which have the same value, and the third being equal to the sum of the other two. The instance given was of a 120- to 240-volt system, which are the approximate values used almost universally for such service. It is, however, entirely feasible to employ exactly the same type of distribution for any other set of voltages, higher or lower, that might be required in special cases, and whatever follows in regard to the 120- to 240-volt system is equally applicable to them.

To bring out clearly the underlying principle of the three-wire system, let us first give our attention to two two-wire systems furnishing current to lamps, as indicated in Fig. 1. Let us assume that we have two generators G_1 and G_2, each supplying 120 volts and each furnishing current to twelve 500-watt lamps, making the load on each $12 \times 500 = 6000$ watts or $\frac{6000}{120} = 50$ amperes when all the lamps are turned on.

The direction of the currents through the mains A, X, Y and B is that indicated by the arrow heads. For convenience the currents are designated I_A, I_X, I_Y and I_B respectively.

Let us now suppose that the points a and b are joined. This may be done without causing any disturbance in the systems since they are entirely separate. Although a is negative while b is positive, a voltmeter connected between them would show no voltage to exist and consequently there is no objection to joining them. We will further assume that the two wires X and Y joining a to c and b to d respectively, are supplanted by a single wire N as in Fig. 2. The current in this wire will be the sum of the currents in X and Y. Referring to Fig. 1, we find that the current in each is 50 amperes, but that the current in X is from c toward a, whereas that in Y is from b to d. The resultant current is therefore zero, since one current is positive and the other negative; that is, no current flowing in N.

An arrangement such as that of Fig. 2 is, as has already been stated, known as a three-wire system. There are other methods of providing the three sources

of voltage required besides that of using two generators in series; they will be presented further on. For the present we will not consider the other methods because the theory of the three-wire system is independent of the apparatus that is used to provide the voltages.

Since the current in N is zero, it would appear that the neutral could be dispensed with. This is, however, true only when the load is balanced; that is, when there are just as many lamps connected between A and N as there are between B and N or, to put it more accurately, when the loads are such that the current in A has exactly the same value as that in B.

To show what happens when the loads are not the same, let us go back to Fig. 1 and assume that three of the lamps between A and X are turned off, leaving only nine in service between these mains as in Fig. 3. The current in A and X then is $\frac{9 \times 500}{120} = 37.5$ amperes, whereas that in Y and B remains at 50 amperes as before. These conditions would also hold if the system were connected as in Fig. 2, and we should have that $I_A = 37.5$ amperes, $I_B = 50$ amperes, and that I_N is equal to the difference of the currents I_X and I_Y of Fig. 3. The former of these is known to be 37.5 amperes, flowing from c to a, whereas the latter is 50 amperes, flowing in the opposite direction: namely, from b to d. That is, we have 50 amperes attempting to flow through the wire N in one direction while 37.5 amperes attempt to flow through it in the reverse direction. The consequence is that the current actually flowing will be the difference between the two, namely, 50 — 37.5 = 12.5 amperes, whose direction will be that of the larger current, that is, I_Y, and will therefore be from b to d as in Fig. 4. If, on the other hand, the load between N and B is made smaller than that between A and N, we would find I_X to be greater than I_Y and the current through N to be from c to a.

The following deductions are to be made from the foregoing: The currents in the outside wires A and B are dependent upon the loads connected between A and N, and N and B, respectively. The currents in A and B attempt to flow through N in opposite directions, consequently we must subtract one from the other to obtain the value of the current in the neutral.

The extreme case is that in which all the lamps on one side are turned off while all those on the other are burning. Thus, let us suppose that the lamps between N and B have been turned off. Then $I_B = 0$ while I_A remains 50 amperes, and I_N will be equal to $I_A - I_B = 50 - 0 = 50$ amperes. That is, when the system is loaded on one side only, the current through the neutral has the same value as that through the outside wire to which the load is connected. This is the maximum value which the current in the neutral can have; as lamps are lighted on the unloaded side the current in the neutral is decreased, until when the loads are balanced no current flows through it.

We may go a step further than in Figs. 2 and 4 by using a single line for the two wires x and y, as is illustrated in Fig. 5, in which the arrows indicate the direction of flow of the currents as before. The manner in which these currents are then distributed in the three conductors, under various conditions of loading, is illustrated graphically in Figs. 7 to 12. The mains are indicated by large pipes which are connected to-

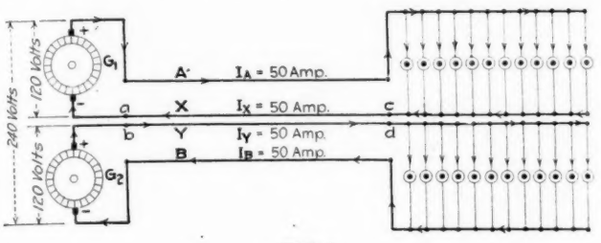


FIG. 1

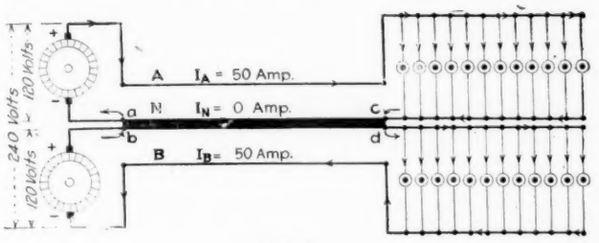


FIG. 2

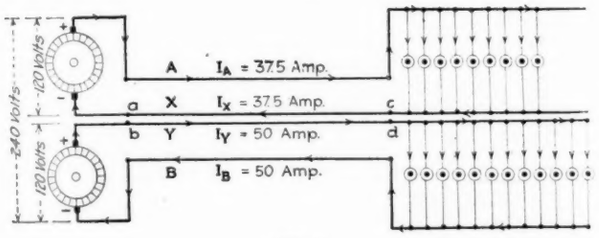


FIG. 3

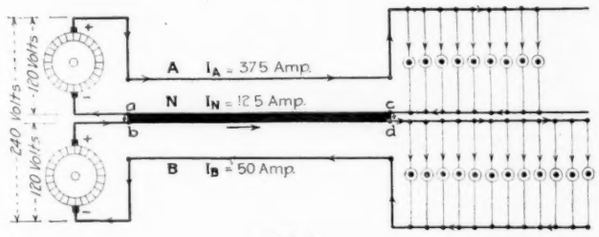


FIG. 4

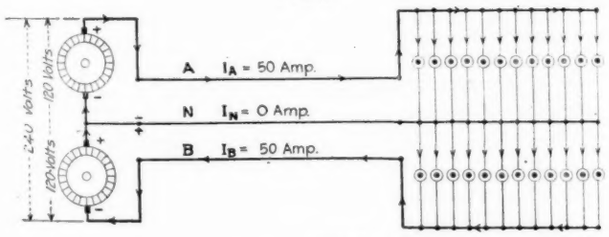


FIG. 5

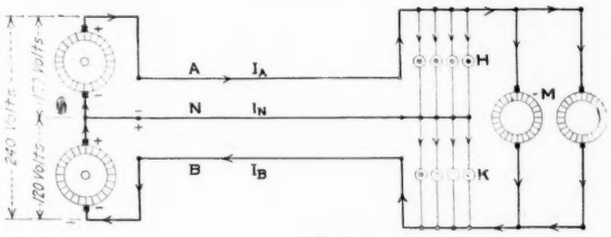


FIG. 6

FIGS. 1 TO 6. SHOWS HOW A THREE-WIRE SYSTEM CAN BE EVOLVED FROM TWO TWO-WIRE SYSTEMS

gether by smaller pipes L which represent the lamps. The direction of the currents is indicated by the arrows. Currents flowing away from the reader are represented by the black sections and those flowing toward the observer by the hatched ones. The magnitude of the current is indicated by the amount of the circle that is occupied by the section. Where no sectioning appears, it means that there is no current flowing in the conductor.

So far we have considered only loads connected between A and N or N and B, that is, across 120 volts. There is, however, no objection to connecting loads directly from A to B—that is, across 240 volts—as for example the motors M shown in Fig. 6. In fact, that is one of the very valuable features of the system. We may use the 240-volt supply for the operation of motors or other large loads, and the 120-volt supplies for the lamps. We thus combine the advantages of a higher voltage for motors with that of a lower one for lamps. The current taken by a load connected to the outside wires has no effect whatever on the current in the neutral. Thus, if all the lamps connected to the system of Fig. 6 were turned off and only the motor load remained on the service, the current in the outside lines A and B would be that required by the load, while that in the neutral N would be zero. This is evident, since there is no connection between the motors and the neutral. Should lights be turned on while the motors are in operation, the currents required by them would divide among the three wires exactly as if there were no motor load, and the motor currents in the outside wires would therefore be increased by the currents required by the lights, while the current in the neutral would be the difference between these lamp currents, which is of course the same as the difference between the outside line currents. Thus, if the motor load M were 20 amperes, the lamp load between A and N (namely, H) where 15 amperes and that between N and B (that is, K) were 12 amperes, we would have as the currents in the three lines, $I_A = 20 + 15 = 35$ amperes, $I_B = 20 + 12 = 32$ amperes, and $I_N = 15 - 12 = 3$ amperes; or, if we chose to use the outside line current, $I_N = 35 - 32 = 3$ amperes.

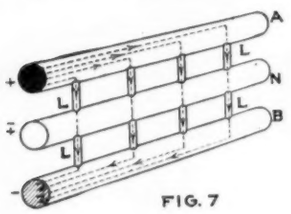


FIG. 7

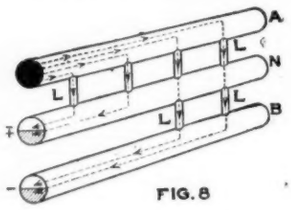


FIG. 8

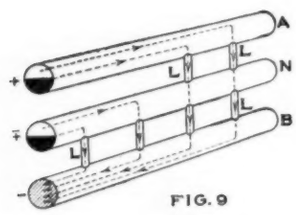


FIG. 9

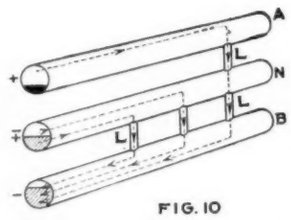


FIG. 10

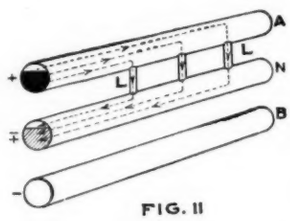


FIG. 11

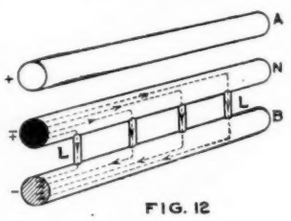


FIG. 12

FIGS. 7 TO 12. SHOWS THE DISTRIBUTION OF THE CURRENT IN A THREE-WIRE SYSTEM

The problem of the preceding lesson was to find the drop in voltage and the power loss in a line of rubber-covered wire 150 ft. long that supplies current at 125 volts to fifty 100-watt lamps and twenty $\frac{1}{3}$-hp. motors, if the size of the wire used is that required by the Underwriters' rulings. The first thing to do is to determine the total current that the line is required to carry, upon which the size of wire necessary is looked up in the table of capacities published by the Underwriters and given in the last lesson. The resistance of that size wire is then determined by consulting a wire table and the resistance per foot as found is multiplied by the number of feet of line. Finally, the drop and loss are computed from the resistance and the current. To get the total current we find the watts (power) required by the lamps and by the motors, and divide by the voltage of the service. The lamps require $50 \times 100 = 5000$ watts. Since the capacity of the motors is given in horsepower, we must multiply it by 746 to obtain the output in watts; for the twenty motors we would have, power output $= 20 \times \frac{1}{3} \times 746 = 1865$ watts. The power input would be somewhat larger than this. If we assume the motors to have an efficiency of 70 per cent. we would have $0.70 \times$ input $=$ output, from which we obtain input $= \frac{\text{output}}{0.7} = \frac{1865}{0.7} = 2664$ watts. The total load is therefore $5000 + 2664 = 7664$ watts, and the current is $\frac{7664}{125} = 61$ amperes. This would call for a No. 4 wire, the resistance of which is 0.248 ohm per thousand feet. Since the line is 150 ft. long and there are two conductors, the total length of wire is $2 \times 150 = 300$ ft. and the resistance is $\frac{0.248}{1000} \times 300 = 0.0744$ ohm. The voltage drop is the current times the resistance, or $61 \times 0.0744 = 4.5$ volts, and the line loss is the current squared times the resistance; that is, $(61)^2 \times 0.0744 = 277$ watts.

Let Fig. 6 represent a 110-220-volt three-wire system suplying current to the lamp load H and K and to the motor load M. Assume that load H consists of eighty 50-watt and thirty 100-watt lamps; that the load K consists of seventy 50-watt and fifty 100-watt lamps; and that the motor load M is composed of one $\frac{1}{3}$-hp. and one 2-hp. motor, both of which are operating at 75 per cent. of full load rating, and assume that the average efficiencies of the motors is 70 per cent. Determine the values of the currents in the mains A, B and N under these conditions.

Moisture in the coal fed to a furnace is a direct cause of loss of heat. It is converted into steam and so carries away the latent heat it has absorbed; also, it is superheated to the temperature of the flue gases and so carries off additional heat due to superheating.

Special Investigations on Power Supply

SECRETARY LANE of the Interior Department has sent to Congress requests for two appropriations for special investigations and report on the power supply. One of these is a request for an appropriation of $50,000 for a survey of the power resources all over the United States. This proposed appropriation is embodied in the Sundry Civil Bill, hearings on which are now being held before the subcommittee of the House Committee on Appropriations. If approved, the work would be done by the Geological Survey. The other request is for an appropriation of $200,000 for a report on the power supply for the industrial region of the northern Atlantic seaboard, extending in general from Boston to Washington. If approved this work would be done by the Geological Survey and the Bureau of Mines in coöperation. The request for the $200,000 appropriation has been approved by the Secretary of the Treasury, and has been forwarded to Swagar Sherley, chairman of the House Committee on Appropriations.

A greatly increased demand for energy will follow the resumption of industry under the operation of normal economic laws and in the face of international competition. If the country is to reap the full benefit of this returning wave of activity, it must be prepared to furnish industry and transportation with an adequate, dependable and economical power supply. Only by increased economy in the production and distribution of power will it be possible for our manufacturers to decrease their production expenses and compete successfully in the world's markets.

In a letter to Mr. Sherley, explaining the necessity for the appropriation just mentioned, Secretary Lane says:

I am today sending to the Secretary of the Treasury a supplemental estimate of an appropriation of $200,000 to be expended in the fiscal year 1920 for a special investigation and report on the power supply for the industrial region of the north Atlantic seaboard extending in general from Boston to Washington.

I respectfully urge that your committee consider this estimate favorably because I believe the investigation will form the basis for a constructive national policy of the highest economic and industrial significance. The country is now passing through a period of transition, which, I firmly believe, will soon be followed by one of industrial activity and expansion. The enormous development of war industries had created an almost insatiable demand for power, a demand that was overreaching the available supply with such rapidity that, had hostilities continued, it is certain that we should now be facing an extreme power shortage. Happily, such a crisis was averted by the signing of the armistice and the ensuing curtailment in the demand for war materials has carried us past immediate danger of a power famine in the industrial districts of the Northeast.

This subsidence in the demand for power will, I think, not be long continued. In a few months and especially in the regions mentioned, I anticipate a greatly increased demand for energy, for which present facilities are inadequate. This demand will follow the resumption of industry under the operation of normal economic laws and in the face of international competition, factors that have been largely inoperative during the war. If the country is to reap the full benefit of this returning wave of activity it must be prepared to furnish industry and transportation with an adequate, dependable and economical power supply. Only by increased economy in the production and distribution of power will it be possible for our manufacturers to decrease their production expenses and compete successfully in the world's markets, maintaining at the same time the American standard of wages and living. That there is opportunity for a system of power supply far more economical and efficient than that now existing in the areas under discussion can not be doubted. It has for its central idea the development of a plan for the generation and distribution of power on a scale far more comprehensive than now exists in this territory and the more efficient use of the power in industry and in transportation.

This result will be accomplished through the interconnection of existing power centers by means of a trunk-line transmission system of high efficiency. Into this trunk line, energy will be fed from hydro-electric plants and steam power stations located at tidewater and near the coal mines. From it will be taken the power required for each principal industrial center and for the electrification of trunk-line railroads and of such branch lines as may be located in metropolitan districts.

Such a comprehensive system of power supply, making use as it would of unutilized or undeveloped water power and of fuel now wasted at the mines, will result in large savings in coal. A very large amount of coal now consumed by steam-power plants can be replaced by the development of water power. Fuel power can be developed near the mines and the wasteful transportation of coal by railroad to that extent avoided. I am reliably informed that as a conservative estimate 50 per cent. of the fuel now used by the railroads in this territory can be saved through the operation of trains by electricity instead of by steam locomotives, because of the much higher efficiency that can be obtained in the economical central station in comparison with the wasteful steam locomotive.

The transmission of this energy as electricity instead of the hauling of coal by rail will relieve the railroads of this territory of an enormous freight burden, thereby making available transportation for the hauling of other commodities. This is a matter of far-reaching importance. Not only would the railroads in the immediate territory be relieved of hauling the coal for their own locomotives, but other railroads supplying them with coal would be relieved proportionately. This easing of the present strain on trackage and equipment would result automatically in an increase in transportation facilities, the necessity for which the country is now facing.

Such a comprehensive system of power supply will give opportunity for the more continuous use of existing power plants through the operation of the diversity factor; that is, power for which there is no demand at a certain time in one locality can be transmitted to another locality needing power at the moment. Spare units in one power center can then be used to assist other power centers in case of emergency or breakdown. A large amount of spare capacity can thus be brought into service and the capital already invested in existing power stations thus made more productive.

That such economies and efficiencies can readily be obtained has been amply demonstrated by the repeated application of these principles to local situations. It is my conviction that they can be applied regionally with even greater success. My purpose in asking for the appropria-

tion is to make possible the investigation necessary to their practical application in this particular region. The report to follow would present a definite plan for development and estimate accurately the savings to be effected.

I am urging the earliest possible action, because I believe such a plan should be formulated at once before we enter upon a new period of industrial activity, so that the new construction that will be required may be coördinated with such a plan and developments that will not harmonize with the plan may be avoided.

This appropriation is requested not as a substitute for but as supplemental to the other estimate submitted by this department for the investigation of fuel and power problems covering the whole United States. Fundamental studies dealing with principles of power supply and fuel utilization are prerequisite to more intensive investigation of the kind that I am bringing to your attention in this letter.

The wording of the estimate for the proposed $50,000 requested by Secretary Lane is as follows:

GENERAL EXPENSES, GEOLOGICAL SURVEY

For a survey of power production and distribution in the United States, including the investigation of methods for the further utilization of water power, and the preparation of reports thereof, one-fourth to be immediately available (submitted) .....$50,000.

Pointers on Pumping Hot Water

BY M. A. SALLER

WHEN special pains are being taken to direct attention to and eliminate all sources of waste and inefficient operation in the boiler and engine plant, it is well to consider the folly of the still widely prevalent practice of introducing cold water into the pump supply line whenever trouble is experienced in pumping hot feed water. Steam is used to heat the feed water to the highest possible temperature because it is appreciated that a rise of 10 deg. in the feed will effect a fuel saving of approximately 1 per cent. After this is done, the engineer or fireman calmly injects cold water into the pump suction line in order to stop knocking in the pump. Instead of heating the feed water to a high point and then cooling it down so that it can be pumped without trouble, the logical thing to do would be to investigate the pump and the piping in order to remove the cause of the trouble, and thus be enabled to take advantage of the high feed temperature.

In pumping hot water it is necessary that the water should flow freely to the pump under head; that is, hot water cannot be lifted by the pump like cold water, because the reduction in pressure caused by the suction of the pump will increase the tendency of the hot water to vaporize and give off steam, which is the cause of the pump knocking. Therefore the first point is to make sure that there is a positive head of water from the heater or hot water tank to the pump. The distance between the level of the pump valves and the working water level in the heater should be not less than 36 in. If this positive gravity head is not available, the pump must be lowered or the heater raised. In some cases the difference in level between the hot-water supply and the pump valves may be 36 in. or more, and still the pump may "balk" at handling the hot water. This may be because the friction loss through the pipe between the heater and the pump is excessive. The piping between the heater and the pump should be of ample size—larger than would ordinarily be run for cold water—and should be as short and direct as possible. Gate valves should be used in the suction line, instead of globe valves, because they offer less resistance. When a long pipe run is necessary between the heater and the pump it should be made "extra large" and should be pitched continuously toward the pump so that there will be no air or steam pockets.

Trouble is often experienced in handling hot water because the pump is too small to handle the load. Pumps for handling hot water should be of such dimensions that the piston will not have to travel faster than 40 to 50 ft. per min. to maintain the desired capacity. If the piston has to travel at a high rate, difficulty will be experienced in keeping a solid body of hot water behind it unless a high head of water is available. If the passages through the pump chamber or valve seats are restricted, it will of course be more difficult for the water to follow the piston, and hence a higher gravity head will be required. If the pump piston travels so fast that the water cannot keep up with it, a partial vacuum is formed and the hot water gives off vapor and immediately the pump will begin to pound or knock because it is vapor- or steam-bound.

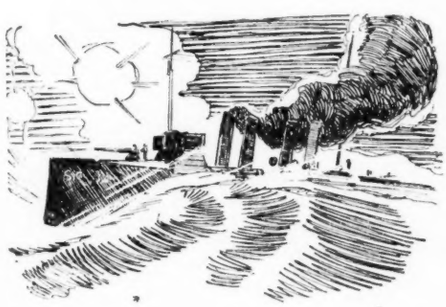
The valves of pumps often cause difficulty in handling hot water. The ordinary rubber pump valve deteriorates under the action of the heat. Pumps for handling hot water should have brass piston rods and metal or special composition valves. Trouble is also likely to occur if the springs on the pump valves are too stiff or tight causing undue friction in passing the water through, all tending to keep the water from freely following the piston. Where there is a long pipe line and the gravity head is small, it is advisable to erect a standpipe in the supply line near the pump so that a supply of water will be available right at the pump and under the maximum head. The standpipe can be made of a section of pipe extended above the highest water level, and it should be vented to the atmosphere to prevent airbinding. Centrifugal pumps require a greater gravity head than is necessary for reciprocating pumps because of the high velocity at which the water must travel. A head of eight to 12 feet should be available over a centrifugal pump.

Difficulty in pumping hot water is merely the result of overlooking one or more factors necessary to insure satisfaction. The main thing to bear in mind is that the hot water must follow the pump piston under gravity head, and to insure this the following points should be borne in mind: Place the pump below the heater or hot-water tank level; run ample size piping, slope the piping toward the pump, avoiding air pockets; eliminate all unnecessary valves and fittings in the supply line; use larger-sized pump for hot water than for cold; keep piston speed below 50 ft. per min.; use first-class metal or composition pump valves; reduce tension on valve springs until just sufficient to close the valves; if necessary place a standpipe near the pump, but do not inject cold water into the hot water line.

Firemen Saved U.S. Transport

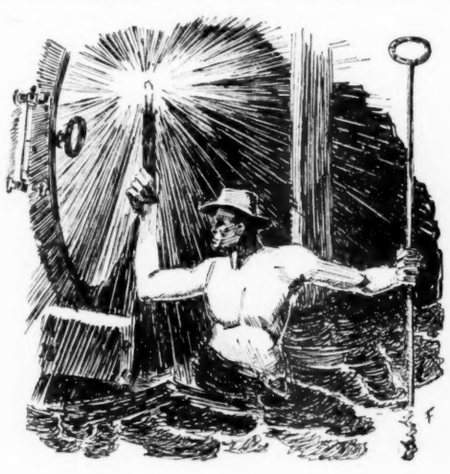
MIGHTY interesting stories are being told these days about how our American boys have upheld the honor of the U. S. A., but most of these stories are of deeds performed on the battlefields of France. There have been thousands of instances of brave and heroic deeds that will never be recorded, because they did not come to the attention of someone with a ready pen. Although most of the thrilling accounts relate to the army, the army-transport service has had its stirring experiences, one instance of which is as follows:

On the afternoon of Sept. 4, 1918, the U. S. Transport "Mount Vernon," formerly the German steamer "Kronprinzessin Cecilie," commanded by Captain Dismukes, left Brest, France, for New York,



but the vessel was destined to participate in a voyage that was far from uneventful, and finally, after being torpedoed by a Hun submarine, reached port only because the firemen in the stoke hole stood by their fires like American seamen.

Upon leaving Brest all water-tight bulkhead doors below deck were closed so that in case the ship was torpedoed there would be a chance for it to remain afloat. This, of course, cut off the stoke holes from other portions of the ship, and one stoke hole from the other. By closing the water-tight doors all avenues of escape from the stoke hole were cut off except a precarious route by way of a ladder and over the boilers.



A route was taken to avoid so far as possible submarine dangers, and the first danger zone was safely passed, and the chances were that the trip would be continued in safety. The unexpected usually happens, and the "Mount Vernon" was no exception. The next morning after leaving Brest, at about 8 o'clock, the ship was steaming along in a calm sea, making about 20 knots, when the lookout saw a periscope on the starboard bow and the ship's guns began firing, as did the destroyers, but all submarines are not blown out of the water even when sighted. Although the steamer was under convoy, a torpedo struck and she at once began settling in the water, but fortunately, the water-tight doors held and prevented the undamaged portion of the ship from filling, although she settled about ten or twelve feet as the water flooded the damaged portion of the hull.

The engineer reported to the bridge that the engines were still running and that the means of communication with the bridge were intact, but that water was rushing

into the fireroom and that there was great danger of a boiler explosion. Fortunately, but one of the firerooms was damaged. What happened in the stoke holes cannot be adequately described. Thirty-six of the fireroom crew lost their lives either by drowning or by being killed by the torpedo explosion, and many others were badly burned by the flames that shot out from the boiler furnaces when the water reached the fire. Fortunately, the inrushing waters helped to end their agony speedily.

In the undamaged boiler room all lights went out with the explosion of the torpedo, owing to the breaking of the electric-light wires. In the darkness, wallowing in water that covered the floor, blinded by fine soot and steam-pipe insulation, and injured by fine pieces of metal, working in fact in the face of almost certain death, these firemen and water tenders stood at their stations and proved themselves heroes. They knew

that they were trapped; they knew that there was danger of a boiler explosion that would completely wreck the ship should it occur, but not a man made a step toward safety. There in the darkness these men continued to stoke the boilers, using for a time the light from live coals or from a torch to determine the water level in the gage-glasses until such time as other illumination could be obtained. Through their heroic efforts the "Mount Vernon" was safely navigated back to port.

This is but one instance of the bravery shown by men who work down below deck, practically unheard of and unseen. It takes nerve to enable a man to stand by his station in times like this when he cannot see or obtain any information as to what is going on about him. Darkness adds terror to any situation, and all honor is due to these men who stood by their station under conditions that called for as much, if not more, heroism than is required to storm a defended position on the battlefield.

Improved Blonck Boiler Efficiency Meter

The coal shortage of last winter and the efforts of the United States Fuel Administration to conserve fuel have given a strong impetus to improvement in power-plant economy. This has been indicated by the increasing demand for instruments of all kinds. Partly because of this increased demand and partly because a new principle has been developed, the improved meter shown at the right in Fig. 1 has been put on the market by W. A. Blonck & Co. At the left of this view is one of the original meters made by the company. Fig. 2 is an enlargement of the new meter.

A primary feature of the new design is that the readings are unusually easy to observe and to interpret. In the older type of Blonck meter no effort was made to supply ranges of scales designed to have the arrows opposite to each other. The latest type is based on the idea of "Each meter built to fit the drafts of the boiler to which it is connected." This results in the indicating oil columns standing one over the other for the highest efficiency of combustion. Hence the fireman need know nothing of the principles of combustion so long as he is capable of manipulating the damper and thickness

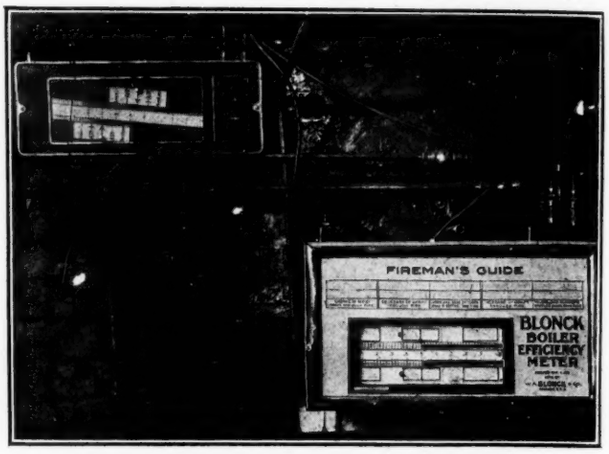


FIG. 1. SHOWING OLD AND NEW METERS

of fuel bed to maintain the columns of oil in line. The minute they get away from each other it is a simple matter for him to refer to a guide, printed on the face of the gage, determine what the trouble is and institute corrective measures.

Parallel motion of the two liquid columns is obtained

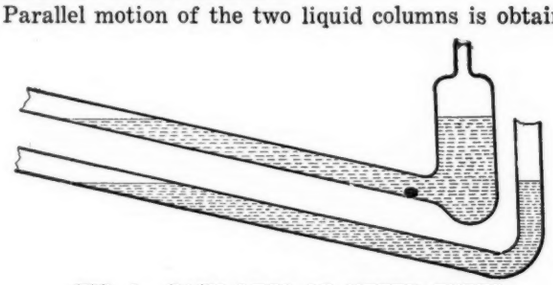


FIG. 3. BACK LEGS OF METER TUBES

by variation in the calibration of the back leg of each tube, as shown in Fig. 3. As the loss in draft through the fire is the factor varying between the widest limits, the back leg of the lower gage is made of nearly the same diameter as the horizontal leg, so that the movement of the fluid in the horizontal leg is retarded. On the other hand, as the drop in draft from the furnace to the damper is less than that through the fire, the back leg of the upper gage is made larger in diameter so that the movement of the fluid in the horizontal leg is accelerated. This simple device for making the two columns of oil travel uniformly together when the ratio of air supply to pounds of coal burned per hour is correct and the instructions for correcting conditions when they become wrong, are the two factors favoring the new meter. A minor refinement is the arranging of the tubes in a horizontal instead of an inclined position, as was the case in the old gage. This is accomplished by putting a slight loop in the tube at the point where the horizontal changes to the vertical. The meter is easily read and the directions simplify the furnace management.

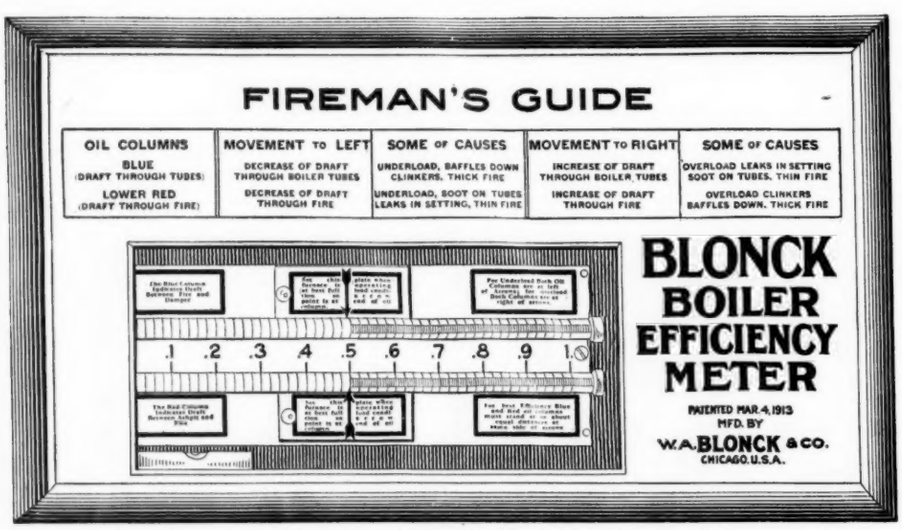

FIREMAN'S GUIDE
OIL COLUMNS
BLUE (DRAFT THROUGH TUBES)
LOWER RED (DRAFT THROUGH FIRE)
MOVEMENT TO LEFT
DECREASE OF DRAFT THROUGH BOILER TUBES
DECREASE OF DRAFT THROUGH FIRE
SOME OF CAUSES
UNDERLOAD, BAFFLES DOWN CLINKERS, THICK FIRE
UNDERLOAD, SOOT ON TUBES LEAKS IN SETTING, THIN FIRE
MOVEMENT TO RIGHT
INCREASE OF DRAFT THROUGH BOILER TUBES
INCREASE OF DRAFT THROUGH FIRE
SOME OF CAUSES
OVERLOAD LEAKS IN SETTING SOOT ON TUBES, THIN FIRE
OVERLOAD CLINKERS BAFFLES DOWN, THICK FIRE
.1 .2 .3 .4 .5 .6 .7 .8 .9 1.
BLONCK
BOILER
EFFICIENCY
METER
PATENTED MAR. 4, 1913
MFD. BY
W.A. BLONCK & CO.
CHICAGO, U.S.A.

FIG. 2. ENLARGED VIEW OF THE METER SHOWN AT THE RIGHT OF FIG. 1

EDITORIALS

Providing an Ample Power Supply for Peace Industries

FOREHANDEDNESS is a characteristic that was noticeably lacking in the United States at the time we entered the great war, and because of that fact we were slow in making our weight felt in the struggle. We had taken little or no thought as to the methods of raising armies, constructing ordnance, building airplanes, extending transportation facilities and meeting the thousand and one other increased demands upon our industrial machinery.

Those were problems brought about by the war, but they were solved eventually, by dint of much hard labor and at vast expense. Now we are confronted by equally important questions that have arisen as a result of the war and that are pressing for solution. Among them the problem of an ample and intelligently arranged system of power generation looms large, because the prosperity of the country is intimately bound up with the matter of power supply to industry.

The requests of the Secretary of the Interior for appropriations for a survey of the power situation in the United States, as explained on page 211, are therefore commendable examples of foresight. Especial interest attaches to the larger of the two appropriations asked for, because it is concerned with investigation of the most densely populated industrial district in the country; namely, the northern Atlantic seaboard. In this narrow strip of territory the greater part of the manufacturing of the nation is concentrated, with the result that there was a serious shortage of power when these plants tried to meet the output demanded by war conditions.

Secretary Lane's plan is intended to prevent the recurrence of this condition under the stress of industrial expansion to meet peace-time needs. It embodies those features that have been found economical and efficient in operation during the war period. It looks forward to the generation of electrical energy by steam plants in the coal fields and by water-power plants wherever they can favorably be built, with interconnection through a trunk-line system. The desirability of a comprehensive system of this kind, by reason of the diversity factor and the freedom from shutdowns due to shortage of power, needs no demonstration to engineers.

The Secretary plans even more than this, however. He sees the eventual electrification of the railroads in the congested area, thereby relieving them of the transportation of a considerable quantity of coal and at the same time conserving the fuel supply by reason of the difference between the efficiencies of the locomotive and the electric generating station. This reduction of the burden on transportation would help to relieve a situation that has been critical for a long time.

The need of a survey such as this appropriation would render possible is beyond the necessity of proof. But no time should be lost in carrying out the work, if its findings are to be of immediate value. It seems to be very generally believed that the country is about to enter upon a period of industrial activity and prosperity such as it has never seen, and power is at the base of the whole industrial structure. Therefore, if we are to meet the new demand with a system of power-producing plants scientifically arranged and coördinated, prompt action is necessary.

Unpreparedness for the duties and responsibilities of waging war cost us heavily in time and money. It is to be hoped that we have learned a lesson from that experience and that we shall enter upon the era of industrial expansion securely fortified against lack of power. The Geological Survey and the Bureau of Mines, under whose guidance the power investigation would be made, have the necessary organization and the experience. They lack only the needed funds and those should promptly be forthcoming.

Carbon-Brush Characteristics

AS EARLY as 1885 carbon brushes were suggested for use on electrical machinery in a patent taken out in that year, and about two years afterward they came into use and are still with us—in a greatly improved form. When we compare the characteristics of the old copper-gauze brush, with all its sparking and arcing, cutting commutators, the necessity of shifting the brushes with each change of load to obtain commutation, etc., with the results obtained with a modern carbon brush applied to the service for which it is designed, the improvement is almost phenomenal.

That the carbon brush has played an important rôle in the development of the electrical industry, especially of direct-current machinery, is generally recognized, and if it had not been for the carbon brush no doubt development of direct-current electrical equipment would have lagged while that of alternating-current apparatus would have been accelerated to even a greater extent than it has.

Many of the types of direct-current machinery in use would be impossible of commercial development without the use of carbon brushes or material of similar characteristics. Chief among these are the high-speed turbo-generator, the sixty-cycle rotary converter and the high-voltage direct-current railway machinery.

However, for many years little consideration was given to the distinctive features of carbon brushes; coefficient of friction, hardness, abrasiveness, lubricating qualities, contact resistance, etc., were practically alien to the art, and only within the last ten or twelve years has real serious consideration been given to the development of different grades of brushes to meet the different classes of service and the various types of machines. The possibility of a universal brush is today

in the same category as that of a universal motor—both have passed into the realm of things apparently impossible.

As long as brushes were used without any consideration of their suitability to the service to which they were being applied, all kinds of commutator troubles were experienced. If a nonabrasive brush happened to be applied to a commutator with hard or too thick mica, blackening and a burning of the commutator was the result. The brushes were often blamed for the trouble; more frequently the quality of the commutator was blamed because of the mica being too hard, when in fact both were contributory causes. Today we know the remedy is to undercut the mica if operating conditions will permit, or else to use a brush that possesses sufficient abrasiveness to cut down the mica.

Undercutting the mica in a commutator has gone a long ways toward improving the results obtained from different types of brushes. At one time graphite brushes were condemned for certain classes of service and looked upon with disfavor in others; today by undercutting the commutator mica they are considered equal if not superior to other grades for these same applications.

Another practice that was the cause of considerable trouble was working the brushes at too high a current density, and that is probably not given the consideration today that it should receive. This trouble generally developed after the machine had been in service for a considerable period, due to the heating of the brushes drying out the lubricant. In many cases the trouble was corrected for the time being by giving the commutator and brushes a bath of oil. This is now considered very bad practice, and brushes of the proper characteristics are selected.

Instead of the old idea that any carbon brush was suited to any service, it has come to be recognized that there is one best grade of brush for each class of service. Beginning in this issue on page 202 is the first of three articles on the "Characteristics, Composition and Application of Carbon Brushes to Electrical Machinery." These articles are unique in their treatment in that they not only tell what the characteristics are, but also show how they are determined by tests and are obtained in the composition of the brush, hence giving a deep meaning to this element that is so essential to the satisfactory operation of electrical machinery.

The Revised A. S. M. E. Boiler Code

ON PAGES 196 *et seq*, is given a résumé of revisions which have been made in Part I, Section I, relating to new installations of power boilers, of the Boiler Code of the American Society of Mechanical Engineers. These revisions are the outcome of four years of practical application of the Code. Frequent meetings have been held by a large committee of experts and specialists in the various phases of the subject, comprising boiler manufacturers and users, manufacturers of boiler materials and appliances, designing and consulting engineers and inspectors, both insurance and governmental, for its interpretation and modification. By this activity the society has placed at the service of the profession, of governmental inspection departments and of legislators who are considering measures of public safety, an instrument embodying the best thought, knowledge and experience of the profession, the cost of which, if the labor expended upon it had been requited at the rates ordinarily paid for such services or measured by the actual worth of the time of its constructors and interpreters, would approach a half million dollars.

In addition to the work of these experts we should like to bring to bear upon the evolution of this Code the practical thought and experience of *Power* readers. Send and get a copy of the complete Code from the Secretary of the American Society of Mechanical Engineers, 29 West Thirty-Ninth Street, New York. The charge is one dollar to nonmembers. Then see how nearly the boilers under your care comply with its requirements. Such a process leads to interesting engineering computations and to a new intimacy with one's plant. This kind of knowledge and the competency to apply it broadens a man and increases his value. If there is anything about the Code or its applications that you do not understand or approve of, or if any suggestions occur to you for its betterment, write to the editor. The Code ought to be clear and understandable to and workable by any of *Power's* constituents, and its extensive and intelligent application by *Power's* constituency would prove its worth or be the best means for pointing out further desirable changes. We hope to see it universally adopted.

If we call the coal operator a profiteer when he makes a profit of $1.10 per ton, what are we going to call the owners of the coal fields who charge as high as $1.50 per ton for the mere privilege of taking out of the ground that which nature has so bountifully bestowed upon us, as brought out recently in the United States Senate Committee investigation of conditions in the anthracite fields?

It has been estimated that it costs one large corporation from forty to one hundred and fifty dollars to hire and train a new workman, therefore this amount is lost if he is discharged or if he leaves of his own accord. From this it would seem that it would be a paying proposition to maintain attractive working hours and to put out a satisfactory pay envelope.

There was a time when boiler efficiency appeared to depend largely upon peculiar tube arrangement. Now attention is being given to proper furnace design and to proper baffling. In focusing attention upon furnace design, engineers are attacking the problem from the right angle.

You cannot improve efficiency by taking indicator diagrams from your engines and records from your CO_2 apparatus and filing them away. They are only guides and helps to a system of management that you must devise, impress and maintain.

Plan your future on the assumption that the present high prices are not going to fall. If they do, you'll be agreeably surprised; and if they do not, you won't be disappointed.

CORRESPONDENCE

Heating System Gradually Improved

In common with other engineers the writer has for years past spent considerable time in study and planning and more than one problem has been gone over and solved during the hours intended for sleep—not the wisest plan from a physical standpoint perhaps, but nevertheless "we all do it" at times.

One heating system, like Topsy, "had just growed," judging by the manner in which the piping was done. In the original design two 6-in. pipes with globe valves led from the two horizontal return-tubular boilers and joined at a 6 x 6 x 5-in. tee from which a 5-in. pipe led. Imagine two 6-in. pipes supplying one 5-in line! On this 5-in. line there was a reducing valve lowering the pressure to 15 or 16 lb. This valve had a rubber diaphragm which frequently blew out—on a cold night about 2 a. m. Just beyond this reducing valve there was a 5-in. connection to the 6-in. exhaust main. This connection was not used, however, as the exhaust steam was only used to heat the coils of a large blower which furnished hot air for some of the shops and dry rooms. There was a lot more exhaust than could be used in these coils, but it could not be utilized in the main heating system because it was necessary to supply higher pressure and temperature in some of the processes, although it was proved that 8 lb. was plenty instead of the 15 lb. formerly used. The condensation from the exhaust was wasted, although the engine, a simple Corliss, developed about 130 hp. and required at least 26 lb. of water per horsepower-hour. This condensate contained 4,732,000 B.t.u. per day of 10 hours, figuring from 60 deg. for raw water to 200 deg. for the condensate, equal to about 400 lb. of 12,000 B.t.u. coal that cost $3.90 per ton in the boiler room.

To get back to the piping layout, the 5-in. line after passing several ells rose vertically about five feet, this riser having a 2-in. drain valve to the returns. The valve was fastened so that the amount of opening could could not be changed, as the employees seemed to like to turn the wheel for pastime regardless of the effect on the heating system. The 5-in. line then split into a 4-in. running north and a 3-in. south, the latter being reduced a short distance farther on to 2½ in., which size was carried about 200 ft., where it divided into several branches. The 4-in. line was carried about 300 ft. without drains to a riser, full size, several branches being taken off without valves on them, making it necessary in case of needed repairs to shut off the whole line. At the extreme northern end there was a 2-in. drain. What course of reasoning would cause a man to think a 4-in. line would condense enough steam to require a 2-in. drain pipe?

The returns from all buildings were connected to the return main without valves—a very poor arrangement, particularly when repairs were necessary in cold weather. All condensate flowed by gravity to a receiver, thence by a pump to the boilers. All supply pipes with the exception of a few short sections exposed to outside temperature were uncovered. The radiating surface was equal to about four miles of 1-in. pipe. The pipe in one building, being actually measured, equaled over 5000 ft. of 1-in. pipe, and there were five other buildings of nearly the same size.

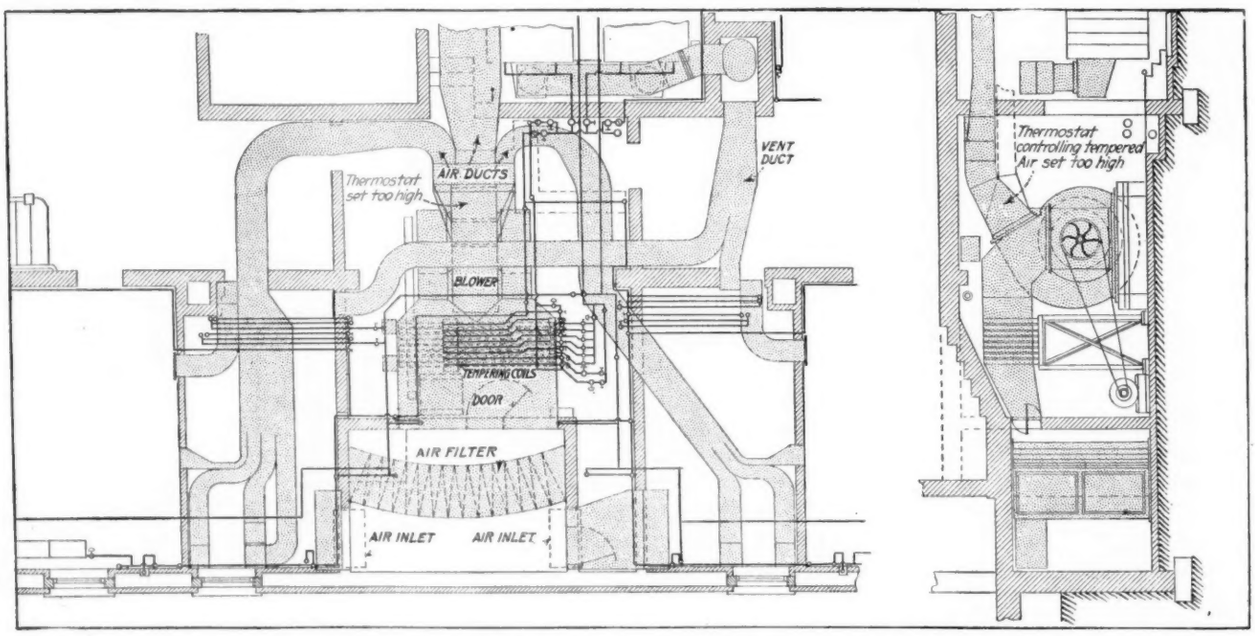
Little by little the pockets were removed, the drains connected and the pipe covered. During this period, however, about 15,000 ft. of additional piping was installed. Although efforts were made to utilize the exhaust, nothing was actually done until about two years ago, when the closed heater was replaced by one of the open type. The returns from the blower coils, as well as the live steam condensate, were led to it and the receiver formerly used was discarded. Then additional coils were connected to the exhaust main. About a year later a cross-connection was made between the live and exhaust systems so exhaust could be used during the day and live steam at night. This necessitated the opening and closing of several valves each night and morning, but proved successful in relieving the situation. The exhaust from two air compressors, a Corliss and a high-speed engine and the feed pumps was all piped to the heater, and there was an abundant supply of exhaust. This improvement resulted in sufficient appropriation of funds to change the entire system.

It might also be said that tests made without the knowledge of employees, using steam in the process, showed that it was unnecessary to carry 14 to 16 lb. on that line—that 8 to 10 lb. was plenty. The changes were not radical or extreme, although effectual, consisting in extending high-pressure distributing lines to feed into the low-pressure system through reducing valves at remote points in the several buildings. This same line supplied the steam used in the processes and then discharged into the heating system. By this means the heating steam pressure could be again reduced so as not to put excessive back pressure on the engine. There is at all times during working hours an abundance of exhaust steam, the temperature of the feed water rarely drops below 190 deg. and it is usually over 200 deg. All coils and drains are equipped with traps of the thermostatic type, and all returns, from whatever device, are connected to a receiver from which the condensate is taken by a vacuum pump and discharged into the heater. Although we are getting inferior fuel and have a larger heating and mechanical load, a comparison of coal consumed with that of the corresponding period four years ago shows practically the same tonnage. Other improvements not bearing directly on heating have been made in the boiler room, and whereas only a short time ago it was difficult to keep firemen, the work is now so much easier that this trouble has disappeared. It took years of hard work planning and persuading, but everyone concerned is financially benefited as a result.

Trenton, N. J. HARRY H. YATES.

Tempering Coil Thermostat Set Wrong

A thoroughly first-class heating system was installed in a school building, tested out by the designing engineers and passed. Some time later one of the engineers of the firm, having business in that town, called on the school superintendent to inquire how things were going. He found that worthy "all het up," figuratively, on account of the failure of the heating and temperature-control systems to function properly. He said that the rooms were too hot and that it seemed impossible to keep the heat down. They were operating the blower system, although the weather was mild, supposedly to get ventilation. The illustration shows the general layout of the heating plant. Thermostats controlled the steam to the direct radiators and also to the tempering coils. Upon investigation it was learned that the thermostat for the tempering coils was set at about 105 deg., so that the air delivered by the fan and duct system was so hot that the rooms were overheated even when the direct radiation was all shut off. The remedy was of course simple and easily applied—when the tempering coil thermostat was adjusted to about 65 deg., there was no difficulty from overheating. The following instructions were then supplied, and no further difficulty has been experienced:



GENERAL ARRANGEMENT OF AIR-TEMPERING EQUIPMENT WITH THERMOSTAT TO REGULATE TEMPERATURE

"We take pleasure in furnishing you the following notes, which may be helpful in the operation of the heating and ventilating plant of your new school building.

Generally speaking, in the milder weather the heating of the building is to be effected by steam rediators only, but in colder weather the air supplied by the ventilating apparatus must assist the heating. The radiators placed in the classrooms have been figured to heat the rooms to only 60 deg. temperature when the outside temperature is between 0 and 10 deg. F. During extremely cold weather the air supply should therefore be kept at a considerably higher temperature than the room temperature—say at 85 to 95 deg. At higher outside temperatures the air supply should be kept around 70 deg. Thus, for instance, on a day of 40 deg. the air should be about 65 deg., but when the outside temperature is around 20 deg. the air supply should be about 75 deg. These figures are only illustrative and should be slightly varied if the best results are secured under somewhat different conditions. As to the thermostats, we wish to reiterate that the less they are manipulated the more satisfactory will be the automatic control of the heat. Should a teacher desire a temperature of 68 deg., the thermostats should be adjusted and left to operate at that temperature and not adjusted to the momentary feelings of the teacher. We advise you to make arrangements with the makers for one or two yearly examinations of the thermostats.

If the schoolrooms become very cold in the morning and conditions should again maintain as last year, when the room temperatures sometimes went below the freezing point, we ask you not to forget that the school can be heated very rapidly by hot air recirculated by the blower. It will be necessary to shut the air-inlet dampers and open the doors between the blower rooms and the basement playrooms, but shut the door between boiler and blower rooms and then run the fan, circulating the air in the building in this manner. We recommend that on very cold days the vent registers be closed. These flues are all located on the inside walls and are consequently not subject to any chilling which might retard the air flow. The capacity of flues depends upon the difference of temperature between the inside and outside air, and the flues therefore become very active in cold weather, because of the extreme temperature difference. The large amount of air drawn from the classrooms by these flues may well be responsible for cold classrooms in the morning. As to the air-inlet dampers, they should be carefully shut off overnight, so as to prevent freezing up the tempering coils, in case of any accumulation of water in these coils, due to leaky valves, etc. Your engineer should be instructed never to open the air inlets unless he has a pressure of at least one pound on the boiler; then if the air valves are properly adjusted, an active steam circulation is certain and freezing and damage is prevented.

J. LEWIS.

New York City.

Cost of Banking Fires

Having read the editorial, "Cost of Banking Fires," in the Jan. 14 issue of *Power*, I offer the following, based on the records of the plant of which I have charge. It does not seem as though the cost of banking coal used should be charged directly to the cost of producing power, but some disposition must be made of this item, which amounts to a considerable in a year.

I am of the opinion that estimating one-third of the coal used for the day's run is used for banking purposes is excessive, at least it is in our plant. If

there are no records, it is difficult to estimate with any degree of accuracy.

This plant is not one of the large stations, but daily records are kept of all operations, supplies, water, etc., and perhaps some information can be deduced from our experience. We have two 125-hp. hand-fired return-tubular boilers operated alternately, under forced and induced draft.

A mixture (about half-and-half) of hard-coal screenings at $2.25 per ton and nut and slack at $4.60 per ton is burned, averaging about $3.50 per ton as fired. An average of 2.75 tons of fuel is burned daily.

The fires are run 12 hours daily, then burned down and banked with straight nut and slack coal, an average of 275 lb. being wheeled out while the fire is brought down and is dumped before the boiler separate from the day's run coal and there is seldom more required.

Operating 360 days a year and banking coal at $4.60 per ton means 49.4 tons used, costing $228 per year for banking. With a coal consumption averaging 880 tons an estimate of one-third is excessive.

Rochester, N. Y. C. M. BOURCY.

A Cooling Pond Suggestion

I once had an opportunity to observe the waste of steam and coal resulting from high-temperature injection water while on testing work on a 10,000-kw. turbine unit. The condenser had 10,000 sq.ft. of cooling surface and the cooling pond was designed to be of ample capacity, but it proved inadequate in hot weather and only about 6500 kw. could be carried on the turbine during the summer when the outside temperature was 82 to 85 deg. Whenever the load exceeded 6700 kw., it was necessary to run the spray-nozzle pressure up from 9 to as high as 19 lb., and under these conditions the vacuum would drop to 23 or 24 in. Temperature readings taken in the center of the pond were far above the air surrounding the pond even when the wind was blowing briskly. It occurred to me that additional nozzles set 10 to 12 ft. higher than the rest would improve the cooling effect quite materially. Tests proved that reducing the number of nozzles reduced the volume of water circulated, but increased the injection temperature greatly; hence it would seem reasonable that increasing the number of nozzles would also increase the volume of water circulated by speeding up the steam-driven circulating pump.

I would like to hear from readers of *Power* who have had experience along this line.

Franklin, Ohio. WALDO WEAVER.

Calculating Heat Loss in Water

A few months ago an insurance inspector made a report that there was oil in our boilers. As we use exhaust steam to heat the building, we decided to trap the returns to the sewer. A few days later an inspector from the Fuel Administration came to view the plant, and he said that we were wasting coal by letting the heating returns go to the sewer.

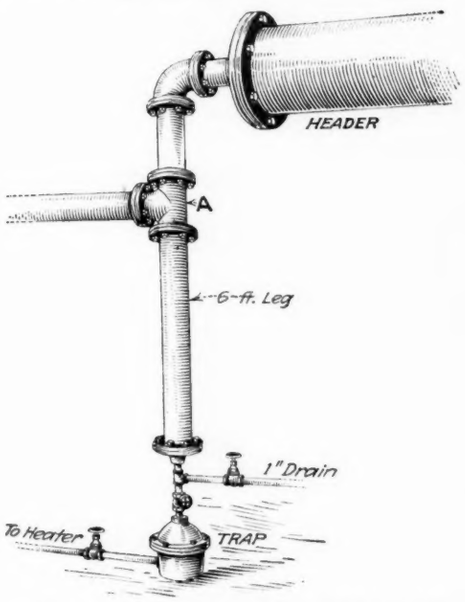
We have a closed heater, and all the steam passes through this heater before it heats the building. The boiler-feed pump is going at a steady rate, and the water going through the coil in the heater has plenty of time to get heated to the same temperature as the steam passing through. I believe we only lose the water going in the sewer and would like to know through *Power* how much heat, if any, we are losing by letting the heating returns go into the sewer. The trap discharging the returns does not leak steam.

New York City. PATRICK MOLLOY.

Changes Improved Matters

When the steam-supply line to a new 250-hp. unit was put up, the chief was on sick leave, and the steamfitters ran the line and connected it to the header, as shown by the sketch, using an elbow at *A*. When this unit was put in operation, large slugs of condensation from the header would carry over, causing frequent shutdowns during the day.

On returning to the plant, the chief, to overcome this trouble, shut down the engine and put a tee in the line as shown at *A*, in place of the elbow. He then connected



ARRANGEMENT OF THE HEADER PIPING

a 6-ft. leg to the tee, connected a trap to the leg and piped the trap to discharge to the heater. The results were very satisfactory.

The exhaust steam from this unit was allowed to escape to the atmosphere. After a few weeks' run, increasing business demanded that the unit be run at night and more coal was consumed than was necessary. During the day run other units supplied exhaust steam to the feed-water heater, keeping the feed water up to 210 deg. F., but at night these engines were not run, with the result that the temperature of the feed water fell to 50 deg. Fahrenheit.

The chief secured a back-pressure valve and installed it in the exhaust line of the new unit, and the exhaust steam was passed through the open heater, with the result that the temperature of the feed water was raised to 210 deg. Fahrenheit.

In round figures the saving on the coal bill averaged about $80 per month. This put a smile on the superintendent's face and another feather in the chief's cap.

Memphis, Tenn. J. A. LANDOLINA.

Avoid Unnecessary Pumping

In many buildings coal can be saved by a proper arrangement of the water piping so that water directly from the city main supplies the lower floors, instead of discharging into a suction tank, necessitating pumping it from that tank to the entire building. The lower floors can be piped separately from the upper ones, and the house pumps will have that much less to do, thus saving wear and tear on the pumps as well as coal. Sometimes it may be advisable to connect the suction pipe of the pump with the city mains direct, in which case it should be of ample size to give full pressure and volume at the pump, thus reducing the work that the pump will have to do. It is advisable to install a gage on the suction pipe to observe the pressure.

When filters are installed in the line, gages should be connected on both inlet and outlet of the filter to show the drop in pressure through the filter bed and to indicate when the filter needs cleaning, and also when the fish trap, meter or any part of the supply line gets clogged. W. T. MEINZER.

Brooklyn. N. Y.

Centrifugal Pumps Made with Wooden Casings

I have read a number of articles relating to centrifugal pumps, but I have not seen anything about their being made with wooden casings. I have built a number of such pumps, using bronze impellers, and they have given excellent service in coal mines.

On a wooden casing sulphur or mine water has an opposite effect to that which it has on a metal one. In the latter it eats away the metal, but on a wood casing it forms a scale which increases in thickness with the life of the pump; this causes the leakage around the impeller to remain more nearly constant as the impeller wears away.

I built the first one of these pumps in 1915, and it has been in operation from 12 to 18 hours every day since then. The first impeller put in this pump was of cast iron, but the others were made of bronze, the third one being put in about a month ago. Where this pump is used the water contains so much acid that a cast-iron pump would last only about two weeks.

When the first bronze impeller was put in, I also put in a bronze shaft, but being designed for load only, it wore so much at the stuffing-box that it broke off in about six months. Since then I have been using a steel shaft, which wears less in the stuffing box and lasts from four to five months. This is a 4-in. pump and works under low pressure.

Since building the first pump, I have been using a shaft with large cross-section, which stands more wear at the stuffing-box before getting too small to carry the load.

One pump, 5 x 6 in., with a bronze shaft, was in service 12 to 18 hours a day for about 13 months before being repaired. The impeller was badly worn, but would have lasted two months longer.

These pumps are all of the side-suction type. I have designed an impeller that is water-balanced when under load. A thrust bearing is used for protection when starting the pump, and also when the water is pumped low enough for air to enter the suction line, which causes the pump to lose its load and allows the water to run back through the pump in case the foot valve becomes worn. This makes the impeller pull toward the suction side and wears into the case unless the pump is stopped. One of these pumps (a 5 x 6-in.) is working on a line 4000 ft. long against a 40-ft. head.

Most builders of centrifugal pumps put the stuffing-box at the end of a long sleeve, which wears and causes the shaft to have considerable spring on account of the impeller being so far from the bearing. With this springing of the shaft the packing soon wears away and allows the pump to take air in at the shaft, which causes it to lose its water.

I put the stuffing-box as close as possible to the impeller and thus avoid considerable of this trouble.

Rimersburg, Penn. J. A. SHAW.

Wrong Piping Layout

Commenting on the letter by D. T. Brown, page 65, in the issue of Jan. 14, the most interesting thing to me is not the phenomenon of varying water levels when cutting such boilers into service, but how long such a piping connection as is shown was allowed to exist before being corrected and what manner of engineer was responsible for the installation originally. It all serves to emphasize the necessity for some form of inspection, by competent men, of all boiler and piping installations.

Had the boiler been cross-connected between the two drums and the cross-connection coupled to a common outlet, the installation would have cost less and been safe, whereas the connection as shown is an invitation to disaster. In connection with the subject of correct piping layouts I am prompted to describe a condition that existed for years in two power plants with which I am familiar. Centrifugal boiler-feed pumps were connected to a common feed line, with one or more pumps of like kind or duplex pumps, without a check valve on the discharge of the centrifugal pumps. Such a connection allowed the water to be short-circuited from the discharge of other units back through the centrifugal pump in case the suction and discharge valves on the centrifugal unit were opened before the pump was brought up to speed. This sometimes resulted in loss of feed to the boilers, if the mistake in operation was not promptly discovered. This condition is easily corrected by a check valve in the centrifugal-pump discharge line. C. B. HUDSON.

Holyoke, Mass.

Generator Heats Excessively

In the Jan. 21 issue of *Power*, page 102, Peter Burkard, writing under the title, "Generator Heats Excessively," requests information regarding the cause of the trouble. I would suggest that he examine the air gaps between the armature and polefaces, for it is apparent that the armature is rubbing on the pole-pieces. This does not have to be sufficient to injure the armature mechanically, but just enough to cause the necessary friction to produce the heat complained of.

Huron, S. D. J. N. CHALLACOMBE.

INQUIRIES OF GENERAL INTEREST

Energy of Coal Utilized by Engine—With an evaporative economy of 8 lb. of water per pound of fuel containing 10,000 B.t.u. per pound, what percentage of the energy contained in the fuel required for generation of steam is utilized by an engine that consumes 25 lb. of steam per indicated horsepower-hour? F. G. G.

One B.t.u. is equal to 778 ft.-lb., and the energy contained in a pound of the coal would be $10,000 \times 778 = 7,780,000$ ft.-lb. With an evaporative economy of 8 lb. of water per pound of coal the energy used for the generation of 25 lb. of steam would be $7,780,000 \times 25 \div 8 = 24,312,500$ ft.-lb. As one horsepower-hour is equal to $33,000 \times 60 = 1,980,000$ ft.-lb., the percentage of fuel energy realized by the engine would be $1,980,000 \times 100 \div 24,312,500 = 8.14$ per cent.

Semi-Bituminous Coal and Semi-Anthracite—What are the characteristics of semi-bituminous coal and of semi-anthracite? W. R. P.

Semi-bituminous coals resemble anthracite more closely than the bituminous, but are lighter and kindle and burn more readily, giving off an intense heat with little smoke and make a clean good fire with little attention. The analysis of semi-bituminous coals is about as follows: Fixed carbon, 70 per cent.; volatile matter, 16 per cent.; sulphur, 0.75 per cent.; ash, 12 per cent. Coals containing 7 to 12 per cent. of volatile combustible matter are classed as semi-anthracite. They burn freer, are lighter, not so hard and have less metallic luster than true anthracite, showing upon analysis about 89 per cent. fixed carbon, 7.5 per cent. volatile matter and about 3.5 per cent. ash.

Velocity in Pump Discharge Line—Having a duplex pump with water cylinders 4 in. diameter and 6 in. stroke and each piston making 100 single strokes per minute, what would be the velocity of the discharge in a 2-in. discharge line working against a pressure of 80 lb. per square inch? N. S.

Without allowing for the space taken up by the piston rods, the area of each piston would be $4 \times 4 \times 0.7854 = 12.566$ sq.in., and with each piston making 100 single 6-in. strokes per minute, the total piston displacement would be $12.566 \times 6 \times 100 \times 2 = 15,079.2$ cu.in. per min. The pressure that the pump works against and other conditions would influence the percentage of slip which under average conditions amounts to about 5 per cent., and the actual volume discharged would be about $15,079.2 \times (1 - 0.05) = 14,325$ cu.in. per min. As the cross-sectional area of a 2-in. discharge line would be $2 \times 2 \times 0.7854 = 3.1416$ sq.in., the velocity in the discharge line would be $14,325 \div (3.1416 \times 12) = 379.9$ ft. per min. or about $6\frac{1}{3}$ ft. per second.

Reconnecting a 500-Volt Motor for 220-Volts—I have a 5-hp. 500-volt shunt-wound motor and wish to reconnect it to operate on a 220-volt circuit; how can this be the most easily done? The armature is series-wound with only two sets of brushes on the commutator. C. K. B.

No doubt the most satisfactory way to do this would be to connect the armature coils in a single parallel winding and the field coils in two groups of two in series and the groups in parallel. The motor will now require a new brush gear that will accommodate four sets of brushes instead of two. These can be secured from the manufacturer of the machine.

Another way of reconnecting the armature, if the brushes are thick enough to span at least three commutator segments, is to connect the armature coils in a double series winding. This would allow the use of the same brushes, but there is always a greater possibility of commutator trouble using this type of winding, consequently additional expense for brush gear required for the single parallel winding is a good investment.

Unbalanced Load on Three-Phase Circuit—A three-phase Y-connected alternator supplies an unbalanced load to a three-wire circuit. The ammeter readings in each of the three phases are 10, 6 and 5 amperes respectively. The load is noninductive and the voltage 2300 between terminals. What is the total power delivered by the alternator? I. R. S.

The answer to this problem may be obtained in two ways. First, find the average reading of the ammeters, which in this case is $(10 + 6 + 5) \div 3 = 7$ amperes, and consider this as a balanced load equal to the average value obtained. Then, when the load is noninductive,

$$Kilowatts = \frac{volts \times amperes \times 1.732}{1000} = \frac{2300 \times 7 \times 1.732}{1000} = 27.89$$

The second method is to calculate the kilowatts per phase. When the load is noninductive, $Kw. = \frac{EI}{1000 \times 1.732}$, when $Kw.$ is kilowatts per phase, E volts between terminals and I amperes per terminal. In this problem the kilowatts in each of the three phases are $\frac{2300 \times 10}{1000 \times 1.732} = 13.29$, $\frac{2300 \times 6}{1000 \times 1.732} = 7.96$ and $\frac{2300 \times 5}{1000 \times 1.732} = 6.64$ kilowatts respectively, or a total of $13.29 + 7.96 + 6.64 = 27.89$ kilowatts.

Series Motor Connected as Shunt Machine—I have a 110-volt small series motor that runs at about 2000 r.p.m. I tried operating this machine with the field coils connected in parallel with the armature, thus converting it into a shunt machine. The motor then got very hot and the speed dropped to 1150 r.p.m. What caused the change in the operation of the machine? A. A. F.

The field coils of a series motor always have a comparatively low resistance and are connected in series with the

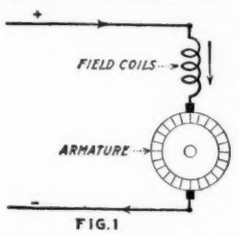


FIG. 1

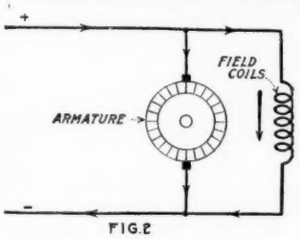


FIG. 2

armature as in Fig. 1, consequently the conductors must have sufficient cross-section to carry the armature current without overheating. When running as a series machine, the current through the field coils is limited by the counter-electromotive force of the armature and not by their resistance.

If the field coils are connected in parallel with the armature, as in Fig. 2, which is the condition in a shunt machine, they have full-line voltage applied to their terminals and the current through them is now limited only by their ohmic resistance. The resistance of the coils being low, the current is very high and consequently they become very hot. In the case of large series motors, connecting the field coils across the line practically amounts to a short-circuit. In the case of small series fan motors, if the circuit is fused high enough, the field coils can remain connected across the line for a few minutes before the temperature becomes high enough to injure the insulation.

The decrease in speed was due to the increased current in the field coils building up the magnetic density to a value where the armature would generate practically the same counter-electromotive force running at 1150 r.p.m. as a shunt machine at 2000 r.p.m. operating as a series motor.

Annual Meeting of the American Society of Heating and Ventilating Engineers

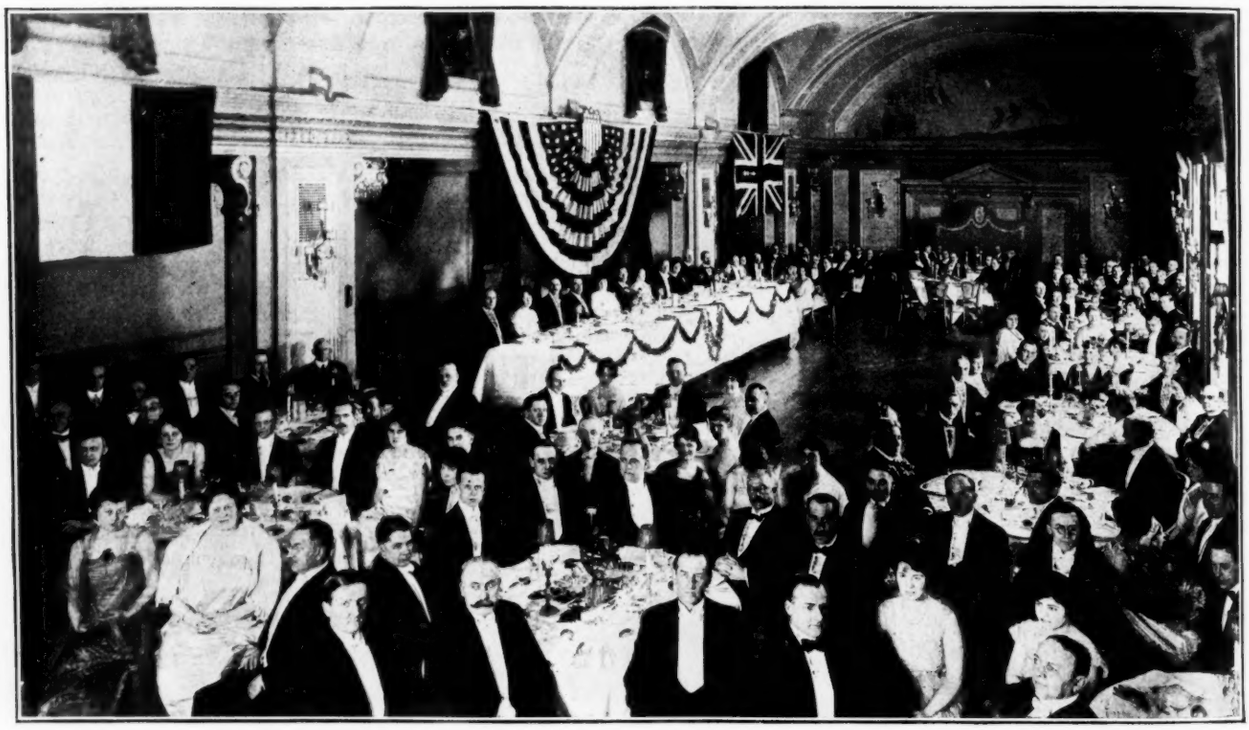
THE twenty-fifth annual meeting of the Society of Heating and Ventilating Engineers was held at the Engineering Societies' Building, 29 West 39th St., New York City, Jan. 28, 29 and 30 and was attended by about 150 delegates.

The opening session was one of the most enthusiastic on account of the announcement of the chairman of the Committee on the Bureau of Research that the goal of $10,000 per year for five years had been reached—in fact, passed—so that the establishment of a research laboratory by the society is assured. Another report that is a source of gratification is the substantial increase in membership of 300 in the last two months, making the total membership about 1200 with the new slogan of 2000 members by 1920.

The order of business in the opening session, beginning at 2 p. m. Tuesday, Jan. 28, was the appointment of tellers for the annual election of officers, address of the president and the reports of the various committees. The officers elected for the ensuing year were as follows: President, Walter S. Timmis, 315 Fifth Ave., New York City; first vice president, E. Vernon Hill, 704 City Hall, Chicago, Ill.; second vice president, Dr. Milton W. Franklin, 240 West Somerset St., Philadelphia, Penn.; treasurer, Homer Adams, 47 West 42nd St., New York City; Members of the Council: Howard H. Fielding, 618 Boston Bldg., Denver, Colo.; Harry E. Gerrish, 501 South Sixth St., Minneapolis, Minn.; George B. Nichols, Albany, N. Y.; Frank G. Phegley, 796 Rose Bldg., Cleveland, Ohio; Fred W. Powers, 5 South Wabash Ave., Chicago, Ill.; R. W. Pryor, Jr., 39 Cortlandt St., New York City; Champlain L. Riley, 101 Park Ave., New York City; F. R. Still, 1400 Russell St., Detroit, Mich.

The Tuesday evening session was the first in which professional papers were read and discussed. The first paper was by E. R. Hayhurst, M.D., of the Ohio State Department of Health, on "Experiments in Air-Conditioning in Houses." This was followed by "The Argument Concerning Mechanical and Natural Ventilation," by E. Vernon Hill, and "Air Washing and Humidification for School Buildings," by Perry West, chief engineer of the Newark, N. J., public schools.

Commenting on the paper and the importance of air washing, E. L. Hallett's remarks were much to the point. He said: "The most important point in Mr. West's paper is emphasizing the necessity for publicity and popularizing of the subject of ventilation most needed at the present time. The public is not aware that it needs good, clean air to breathe. Today we use pure water to drink, but twenty years ago purification of water was unheard of. The Government inspects the food we eat and requires that it meet the pure-food regulations. Yet so far, there is one element that comes in contact with our bodies that hasn't been corrected, and that is the air we breathe. This is a matter that I should like to see taken up by our Research Bureau, and it is one of the most important subjects they could investigate."



GROUP OF HEATING AND VENTILATING ENGINEERS AND GUESTS AT THEIR ANNUAL DINNER DANCE

The next session was Wednesday afternoon at 2 o'clock. Papers on "Air Duct Design," by Leo Kraft, "Arrangement of Heating Pipes an Important Factor in the Decay of Factory Roofs," by F. J. Hoxie, and "Dust Determination in Air and Gases," by E. R. Knowles, with their discussion, occupied the time. The evening session Wednesday was opened with a topical discussion on clean-out openings in heating boilers. James A. Donnelly urged standard specifications requiring two 2-in. openings in the lower part of each boiler and the installation of a surface blower. He said in part: "A boiler should be thoroughly cleaned before it is first operated to get rid of the awful mess that accumulates there. I have found everything from carbon, core mixture, to 6 in. of mud in the bottom of new boilers. This should be washed out before the boiler is fired, and this can be best done by the use of plenty of hot water. The code should provide for openings so that they can be cleaned out at the start and then there won't be any priming."

P. J. Dougherty said: "I agree with everything Mr. Donnelly has said. It is absolutely essential that boilers be

cleaned at the start if trouble is to be avoided later." The hearing on the code for testing low-pressure heating boilers was then opened after Professor Allen had read the proposed code for 1919, which had been drafted by the committee, of which Homer Addams was chairman. Frank K. Chew moved that the report as read by Professor Allen be accepted as the 1919 code. The motion was adopted by a unanimous vote for the first time in the history of the society on this subject.

Frank I. Cooper, chairman of the Committee on Schoolhouse Standards, reported very complete findings, with numerous charts showing percentages of floor areas in schools all over the United States used for education, administration, heating and ventilating, and other purposes. The best school building in the country was designed, it was pointed out, to have 67 per cent. of the floor space devoted to educational purposes. The worst school building in point of educational facilities he found to be one of the largest in New York City. From 3 to 12 per cent. is the average floor space in school buildings given to heating and ventilating, Mr. Cooper found. C. B. J. Snyder, superintendent of buildings of the New York City Board of Education, expressed the opinion that 10 per cent. of the space should be given to heating and ventilating. Chicago authorities say that 7 per cent. is sufficient. In many instances a surplus of space has been given to coal storage, the report showed, which tabulated 141 school plans in as many cities.

E. L. Hallett said: "I believe that too much space cannot be given for the storing of coal reserve, even if it forces the superintendent of the school out of office room. As superintendent of engineering in the St. Louis schools, I have found it cheaper to deliver our entire winter's coal supply in the summertime than month by month. I have saved from fifty cents to a dollar a ton by such deliveries, so you can see how much money can be saved by having adequate space to store coal. I have also found that the most unsatisfactory schools in our St. Louis system are those where there has been crowding in the boiler rooms."

The Thursday morning session was opened by President Still reading a paper by F. A. De Boos on "Fuel Conservation by Means of Automatic Temperature Regulation," which was then discussed, as follows:

H. L. Williams—There is need of seeing that the janitor of school buildings has an interest in and understands how to use the automatic control system to make it effective.

C. R. Bradbury — In one of Washington's Government buildings steam is purchased but the occupants are in the habit of opening the window rather than shutting off the radiator. This makes clear the need of wider use of automatic control.

Perry West—I am positively in favor of automatic control, but there is need of a better understanding of the use and value of such service.

F. R. Still — In this work the use of tne wet-bulb thermometer for taking temperature should become general. A wet-bulb temperature kept right will enable the dry-bulb temperature to vary 8 deg. without complaint.

The report of the Committee on Automatic Heat Control by Chairman Samuel R. Lewis was then read and discussed, followed by a paper by John R. Allen on "A Test of the Conductivity of Window Shades." Discussion was then taken up of the topic "Capacities of Automatic Roof Ventilators."

The final session, on Thursday afternoon, was opened with the reading of Konrad Meier's paper on "Limiting the Fuel for Domestic Heating," by the secretary, by abstract. As the paper was written last August, before the armistice was signed, it was more timely then in that it offered ideas for the solution of problems arising from war conditions. Average coal consumption is computed per 1000 cu.ft. of space. Records are given covering a large number of American residences which give a requirement of approximately 5 B.t.u. per cu.ft. of heated space for city residence, 6 B.t.u. for suburban brick houses and 7 B.t.u. for frame houses. Five causes of waste are shown, all of which, it is explained, may be avoided to some extent. Construction can be improved, ventilation can be shut off where not needed, boiler efficiency can be raised, the application of heat can be brought more into harmony with the needs, are some of the suggestions made.

John R. Allen said: "There is a distinct difference in localities as to the amount of fuel needed. Now, in Minneapolis we burn less coal with the temperature at 30 deg. below zero than they do in Detroit, where the climate is less severe, and we use smaller heating units, too. The reason for this is that in my part of the country every house has a 'winter overcoat,' and has proper insulation to hold heat."

The paper that followed considered another phase of the same topic and advanced the theory that in fuel consumption weather control over heating is a most important factor. The subject was "Engineering Economics of Heating," and was presented by M. William Ehrlich, of New York, (published in *Power*, Feb. 12 and Mar. 5, 1918.) Many figures were presented, representing actual conditions in cities all over the country, in the development of the theory. While the human element modifies the results somewhat, control over heating is the most important factor, it is explained. Combining the two, all figures are at once placed on an empirical basis and the coal consumption is determined by this new condition. Formulating this theory gives a method for predetermining the coal requirements, which in turn becomes a standard for measuring the relative fuel economy of any heating plant. The new theory, it is asserted by the author, proves that it is not fair to relate coal consumption to cubic contents of the building heated, nor does a relation of coal consumption to installed heating surface give conclusive results.

The last paper was on "Byproduct Coke," by William T. Hannes, of Detroit.

The Entertainment Committee acquitted itself with credit throughout, the closing event being the annual dinner-dance. held at the Hotel McAlpin, which was well attended and thoroughly enjoyed. Following Toastmaster Still and a speech by President Timmis, Mr. Staples, of Buffalo, made a speech and W. F. Wetmore entertained with recitations, both receiving hearty applause.

Annual Meeting Indiana Engineering Society

During its thirty-ninth annual convention, held from Jan. 23 to 25 at Indianapolis, the Indiana Engineering Society devoted an entire session to the discussion of power-plant subjects. A. R. Holliday, Federal fuel administrator for the state, spoke of the phenomenal rise in the price of fuel in Indiana. Screenings that had formerly cost 90c. per ton rose to $5 per ton. In 1915 seventeen million tons were mined, and in the next three years the figures jumped to nineteen, twenty-four and thirty million tons respectively, the rate in October, 1918, being thirty-six million tons. The speaker described the general work of the Fuel Administration and indicated that in Indiana it had been so successful in its campaign of education that there was enough coal on hand in the fall to take care of any kind of a winter even though the mines shut down, and that now there was such a supply on hand that the mines could remain inoperative for 20 days without anyone suffering.

Prof. Frank C. Wagner, of Rose Polytechnic Institute, presented a paper on fuel conservation in the steam plants of Indiana, with special reference to the grading of the plants from the questionnaires sent out by the Fuel Administration. For most of the first-class plants the rating averaged about 75 per cent. Throughout the state 600 plants were graded; 483 of these were power plants, the others being used for heating only. Of these 483 plants, aggregating 287,884 hp., 38.6 per cent. reported that they had made improvements or would shortly do so; 93 per cent. reported no defects in boiler settings, although the speaker explained that many took the occasion to plaster up the holes before the reports were made. Feed-water heaters were used in 77 per cent. of the plants; 57.2 per cent. weighed the coal, 12 per cent. measured the feed water, 12½ per cent. had draft gages, and 10 per cent. had CO_2 apparatus. The average marking was 70.13 per cent.

Nine plants had a rating of 95 per cent. and better, and 16 plants were graded between 90 and 95 per cent. The principal advantage accruing from the campaign was in the education that certain economical operating conditions must exist, and that complete operating records must be available before any great improvements in economy could be expected.

George W. Hubley, administrative engineer for Kentucky, gave the following figures for that state: Of 1199 questionnaires sent out to the plants in the state, 557 were returned. Nineteen plants were rated between 81 and 93 per cent.; 314 between 61 and 80 per cent.; 198 between 41 and 60 per cent.; 26 between 23 and 40 per cent.; the average for the state was 62.1 per cent. Referring to the 557 plants, 57.3 per cent. weighed the coal, 7.3 per cent. metered the feed water, 76.9 per cent. had feed-water heaters, 11.9 per cent. had draft gages, and 5.5 per cent. used CO_2 apparatus.

Public Utilities in the War Period

H. O. Garman, chief engineer of the Indiana Public Service Commission, read a paper on "Public Utilities in the War Period." He said that the making of large quantities of munitions within the borders of the state had resulted in an unprecedented demand on the power stations of the public utilities. Before the war period the power consumers of electricity had succeeded in reducing the power rates to but little more than the switchboard costs, and the largest one item of cost was coal. Coal costs jumped from $1.25 and $1.50 per ton to $3.50 and $5. The coal cost per kilowatt-hour ran from 0.35 to 0.75c. before the war, and during the war it ran up to 1 to 3c., and in some cases of bad management and poor maintenance to as much as 4c. per kilowatt-hour, the coal consumption ranging from 17 lb. downward to 3½ lb. of coal per kilowatt-hour. To overcome the increased cost of production the commission had arranged for surcharges for electrical energy based on cents per kilowatt-hour, and not per cent., for the reason that the large increase in cost of electrical energy was caused by the unprecedented rise in the cost of coal, and coal did not enter into the various rates with an equal percentage. For example, assume a coal cost of 0.5c. per kw.-hr., a power rate of 1c. per kw.-hr. and a lighting rate of 10c. per kw.-hr. If the coal cost doubled, then there would be added 0.5c. per kw.-hr. to each of the rates, or the new power rates would be 1.5c., an increase of 50 per cent., and the new lighting rate would be 10.5c., or an increase of only 5 per cent. Power rates are always competitive rates, for utilities must bid against the cost of power in the isolated plants. The potential competitive element is always a factor in power rates, but on account of the higher cost of labor, prime movers and coal, the competitive potential has been raised so that power rates will never settle back to their original datum, or level, although they will settle back some from the present abnormally high costs.

Heating Plants Profitless

Central-station heating plants were sorely pressed, both hot-water and steam plants; many of them would have abandoned the service entirely if the commission would have permitted it, and if it could have been done without causing suffering to their patrons. None of the 37 heating plants in Indiana made a fair return on its value, and by agreement three of them have abandoned service permanently.

On account of incompetent management of many of these heating plants, comparatively large investments and extravagance of consumers, it costs about twice as much to heat a dwelling from a central station as it would to heat it independently. During the last year the commission in coördination with the United States Bureau of Standards has developed and adopted a set of standards for central-station hot-water heating, which, together with close commission supervision, is probably responsible for saving many of the Indiana heating plants from the junk heap.

Next to the heating plants the gas plants were sorely pressed by a shortage of labor, zoning out of coal, poor gas-coal substitutes, high prices and poor management. Water-supply utilities suffered only the usual war increases in cost of purification materials, coal and labor, and when normal prices are restored again they will be back nearly to a pre-war basis. New economic conditions are facing the street railways and interurban railways, and the safety of the investments is being seriously impaired. Telephone utilities have suffered the least of all, due to war conditions.

In conclusion it was observed that the public utilities situation is clearing up immensely compared with what appeared to be the outlook one year ago. Standards of service will be much better maintained in the immediate future, and when the price of coal is reduced, the abolition of the war surcharges may be anticipated.

The following officers were elected for the ensuing year: Prof. G. A. Young, president; Charles Cheney, vice president; Charles Brossman, secretary-treasurer.

Midwinter Convention, A. I. E. E.

The American Institute of Electrical Engineers will hold its seventh annual midwinter convention, Feb. 19-21, 1919, in the Engineering Societies Building, 33 West 39th St., New York City. The convention will open Wednesday afternoon in joint session with the American Institute of Mining Engineers, at which five papers on electric welding will be presented: "Microstructure of Iron Deposited by Electric Arc Welding," by G. F. Comstock; "Path of Rupture in Steel Fusion Welds," by S. W. Miller; "Welding Mild Steel," by H. M. Hobart; "Electric Welding in Shipbuilding," by S. V. Goodall; and "Fusion in Arc Welding," by O. H. Escholz. Wednesday evening will be devoted to a lecture by Dr. John A. Brashear, on "An Evening with the New Astronomy," which will be followed by an exhibition of technical moving pictures as adopted by the United States War Department for the instruction of the Army in the operation of various mechanical devices.

On Thursday morning there will be a technical session opened by an address by President C. A. Adams, followed by the presentation of two papers: "The General Equation of the Electric Circuit—III," by C. P. Steinmetz; and "Review of Work of Subcommittee on Wave-Shape Standard, of the Standards Committee," by H. S. Osborne. Thursday afternoon will be devoted to a technical excursion to the Brooklyn Navy Yard. Opportunities to visit the prominent electrical plants in New York and vicinity during the time of the convention have also been provided. On Thursday evening there will be a dinner-dance at the Hotel Astor for members and guests in attendance at the convention.

Friday morning's technical session is under the auspices of the Electrophysics Committee and papers will be presented on: "Ionization of Occluded Gases in High-Tension Insulation," by G. B. Shanklin and J. J. Matson; "The Dielectric Strength of Air Films Entrapped in Solid Insulation," by F. Dubsky; and "Abnormal Voltages in Transformers," by L. F. Blume and A. J. Boyajian. On Friday afternoon the final session of the convention will be held under the auspices of the Telegraphy and Telephony Committee, at which the following papers will be presented: "Aëro Telephony," by E. B. Craft and E. H. Colpitts; "Theory of Transient Oscillations," by John R. Carson; "Telephone Circuits with Zero Mutual Induction," by W. W. Crawford.

Petroleum oil as it issues from the well contains certain light fractions of the petrol and paraffin series, which it is not only desirable to extract from the crude by distillation, on account of their higher values, but which, if left in the crude oil and used as fuel would be a wasteful procedure, and further, would lower the flash point, which has been very properly fixed for fuel oil, says the *Engineer*, London, by British authorities, namely, Lloyds' Register of Shipping, 150 deg. F., British Admiralty, 175 deg. F., London County, 175 deg. F. The crude oil is therefore subjected to what is known as a "topping process," which is a distillation which cuts out those lighter fractions, leaving a product having a calorific value of about 19,000 B.t.u. per pound.

Progress in Turbine Ship Propulsion*

By FRANCIS HODGKINSON
Chief Engineer, Machine Department, Westinghouse Electric and Manufacturing Co.

THE high-speed turbine with the floating-frame reduction gear, invented by Admiral G. W. Melville and John H. Macalpine, has proved its reliability not only for use on land, but in marine service as well. The records of the Westinghouse Electric and Manufacturing Co. show that between November, 1915, and September, 1918, 31 ships using this equipment had been put into service and of these 23 have had no trouble with the propulsion machinery, 4 experienced some trouble due to improper lubrication, 2 to defective material, and 1 to errors in assembling the apparatus. None of these troubles was vital, and all were of a kind that might happen to any machine.

As large turbines are now being built which can deliver to the shaft about 80 per cent. of the energy theoretically available in the steam supplied to them, it is evident that further improvements in the turbine itself will not materially raise this efficiency. Therefore to improve the performance of the ship's power plant, a matter of importance in view of the rising cost of fuel, we must pay more attention to the auxiliaries and study the practice of the central-station engineer, who has been able to obtain excellent results in reducing power costs.

Feed-Water Heating Systems

A much-desired system is one that will automatically maintain a predetermined temperature in the feed-water heater at all times, bleeding from the main turbine when more heat is needed and permitting surplus steam from the auxiliaries not condensing in the heater to reënter the turbine and do useful work. Such heat-balance systems have been used on land for some time and should be developed for use at sea. Automatic valves that maintain the proper steam pressure and temperature balance are already available.

With the advent of turbine-driven auxiliaries and electrical winches, all the exhaust steam produced can be kept free from oil, so that the less expensive and more efficient open type of heater can be used in place of the standard marine tubular type.

Central-station engineers are today considering the use of steam at pressures as high as 600 lb. because of the higher operating efficiency thus secured.

Economizers do not appear to have been used on ships, but there seems to be no reason why they should not be applied on express steamers where they should permit a net gain of about 10 per cent. in fuel consumption.

Superheat has never been recommended in connection with the old slow speed direct-connected turbines, but superheats of as high as 100 deg. F. should present no difficulties with the high-speed geared marine turbine. This should save some 4 or 5 per cent. of fuel.

With a properly designed turbine the steam consumption will be 7 per cent. better with 29 in. of vacuum than with 28 in. The desirability of the use of such a vacuum is therefore obvious, but it can be obtained only when the most efficient condensing apparatus is used and when the greatest care is exercised to prevent air leakage.

Importance of the Oiling System

The oiling system is vital to the proper operation of the turbine, and too much attention cannot be given to the layout of the system so as to insure an extreme degree of simplicity and reliability. In an ideal system the oil pumps should be placed at as low a level as possible; the drain tank should be large and thoroughly drain the turbines through large-sized pipes; the pump suction should be placed several inches above the bottom of the drain tank so as to avoid drawing dirty oil, but an auxiliary suction should be provided also that the tank can be completely emptied for cleaning; the pump should discharge through coolers into an overhead gravity tank located about 20 ft. above the machinery; duplicate coolers should be provided so as to permit either one to be cut out of service; the oil pressure in the coolers should be higher than the water pressure so that no water can mix with the oil in case of a leak; the overhead gravity tank should be supplied with a strainer and should contain a float-operated valve for controlling the speed of the oil pumps; and arrangements should be provided so that the presence of water in the oil can be immediately detected.

Cross-compound turbines, in which the steam regularly flows first through the high-pressure cylinder and then through the low-pressure cylinder, are essentially designed for vessels that always operate at their maximum speeds. Where cruising speeds are required, the divided-flow turbine is applicable. In this type all the steam passes through an impulse element in the high-pressure cylinder and then divides, one portion continuing through the high-pressure cylinder to the condenser and the other portion going through a separate low-pressure cylinder and then into the condenser. For cruising, the low-pressure cylinder can be cut out of service. This arrangement is also adaptable to constant-speed steamers. It will give nearly as good performance as the cross-compound type and has certain constructional advantages.

A modification of the divided-flow type is the series divided-flow turbine, in which certain of the turbine elements are operated in parallel for maximum speeds and in series for reduced speeds. This obviates the use of a separate cruising turbine.

Simple Turbine for Patrol Boats and Cutters

For patrol boats and cutters an exceedingly simple form of turbine has been designed. It consists of a single reentry impulse wheel with reversing buckets cut in the shrouds of the ahead blades, and with steam pressure of 330 lb. and 27 in. vacuum, the steam consumption by actual test is 14.9 lb. per shaft horsepower-hour at 600 hp.

It is frequent practice to provide two valves, one for ahead and the other for astern, but as this arrangement is somewhat inconvenient and permits both valves to be opened at the same time, the Westinghouse company prefers to provide a single valve which controls the steam in both directions and is more easily manipulated.

There is much difference of opinion as to the relative merits of the electric and the geared turbine drive. Electric drive is being installed on certain battleships, and while its operating success is certain, the question as to whether the increased complications, increased cost and weight of machinery, and increased steam consumption per propeller horsepower are warranted, can only be answered by future developments.

One system of electric drive has been proposed which has promise of excellent economy. This consists of the use of a number of small Diesel engines, with cylinders not greater than ten inches in diameter and therefore well within the limits of reliability, each of which is to drive a small generator. These units can of course be located anywhere in the ship.

*Abstract of paper read before the Society of Naval Architects and Marine Engineers, Philadelphia, 1918.

Information and Education Service, Department of Labor

The Working Conditions Service, Department of Labor, announces in connection with its plans for safety work during the coming year that the following codes will be first taken up, with the coöperation of the Bureau of Standards, Department of Commerce:

Plant arrangement, including routing of material and product, design of buildings and layout of plant; yard entrance and exit gates, roadways and walkways, railroad tracks, material piles, clearances and illuminations; fire hazards, including fire-fighting equipment, water mains and hydrants, spacing between buildings as related to oc-

cupancy, and arrangement of yard material as related to occupancy of buildings.

Building equipment, including stairs and exits, skylights, ladders, railings, and toeboards (fixed), platforms and scaffoldings (fixed), illumination and window cleaning.

Fire prevention and protection.

Elevators, including shaftways and hatchways, shaftway equipment, cables, counterweights, guide rails and bumpers, landings, landing doors and gates, cars and car construction, machines, machinery and machine rooms, car and machine safety devices, control and signals, and escalators.

Cranes and derricks, including controllers and wiring, hoist mechanism and brakes, clearances, bridge, tower and gantry cranes, locomotive cranes and derricks, and handpower cranes.

Conveyors and conveying machinery.

Steam engines and turbines, including piping and valves, overspeed devices and governors, safety valves and guarding.

Hydraulic machinery, including piping and valves, overspeed devices and governors, safety valves and guarding.

Oil and gas engines, including piping and valves, overspeed devices and governors, safety valves and guarding.

Mechanical transmission of power, including shafting and bearing, shifters, shippers and belt fastenings, gears, clutches and friction devices and control of power.

Head and eye protection, including protectors for chippers, riveters, calkers, babbitting and similar operations, sealing, grinding and similar operation, dipping and brush coatings, sandblasting, oxyacetylene welding and furnace work, and electric-arc welding and cutting.

Lumber and wood-working machinery.

Textile machinery.

General chemicals, including acids, anilines and coal-tar derivatives, caustic alkalies, gases now not used for power production, oxidizing materials, phosphorus and matches and alcohols.

Explosives.

Rubber and composition goods.

Proposed Engineers' License Law for West Virginia

A bill has been introduced in the West Virginia Senate by Senator Luther, of McDowell County, requiring the licensing of stationary engineers. The measure in brief provides:

That it shall be unlawful for any person to operate a steam boiler or engine in the State of West Virginia of more than 50 hp., except locomotive boilers and engines, and other boilers and engines under the jurisdiction of the United States Government, without having been duly licensed so to do, as herein provided. And it shall be unlawful for any owner or user of any steam boiler or engine, other than those excepted, to operate or cause to be operated, such steam boiler or engine without a duly licensed person in charge.

The office of the chief examiner of engineers is created. The Labor Commissioner shall appoint as chief examiner with the approval of the Senate some citizen of the state entitled to vote, who has had not less than ten years' experience as a practical steam engineer and whose term of office shall begin May 1, 1919, and shall continue for four years and until his successor has been appointed and qualified, unless he is sooner removed. He shall give bond, with good security, to be approved by the Governor, in the penalty of $3000, for the faithful performance of all his duties and for accounting for and paying over, as required by law, all money which may come into his hands by virtue of said office, and such bond shall be filed in the office of the Secretary of State. The Labor Commissioner may remove such officer in case of incompetence, neglect of duty, gross immorality or malfeasance in office, and in case of a vacancy, whether occurring by removal or otherwise, may declare the office vacant and fill the same by appointment for the unexpired term.

The Labor Commissioner of the State of West Virginia, together with the chief examiner of engineers, shall divide the state into three examination districts. The chief examiner shall appoint an examiner for three districts outside of that occupied by the chief engineer, who shall have had five years' practical experience in the operation of steam engines and boilers and whose bond shall be in the sum of $2000. The said district examiner shall receive a salary of $2000 per year and not to exceed $1200 for traveling expenses while in the discharge of his official duties, which shall be paid by the auditor from funds appropriated for that purpose, upon receipt of a properly certified expense account.

Any person who desires to act as a steam engineer or fireman shall make application in the district in which he resides, to the district examiner of steam engines for a license so to act, upon a blank furnished by the examiner, and shall pass an examination on the following subjects: The construction and operation of steam boilers, steam engines and steam pumps, under such rules and regulations as may be adopted by the chief examiner.

Any person to whom a license is issued under the provissions of the act, shall, at the expiration of one year from the date thereof, be entitled to a renewal thereof for one year unless, in the opinion of the district examiner of his district the person shall have the right to appeal to the chief examiner provided for in Section 8.

It shall be the duty of each examiner to notify every person operating a boiler or engine in his district mentioned in Section 1 and not included in the exceptions therein specified, to apply for a license under the act within sixty days and give such persons a reasonable opportunity to take the examination therefor.

Any owner or user of boilers or engines, or any engineer or fireman who after being notified as provided in Section 9 of the act, violates any of the provisions of the act, shall be fined not more than $50 and not less than $25. The examiners shall have the authority, and are hereby empowered to visit any and all engine rooms or boiler rooms in the state at all reasonable hours, for the purpose of seeing whether unlicensed persons are operating steam engines or boilers.

New Airplane Engine

The Liberty engine, which is of the multicylinder V-type, weighs, in the 400-hp. size, over 2.7 lb. per hp., with accessories and including cooling water and radiator. A new engine now being developed by John W. Smith, of Philadelphia, is expected to deliver the same horsepower. It has ten cylinders 5½-in. bore by 6½-in. stroke, and an estimated weight of but 1.3 lb. per hp. A British engine with nine of these cylinders is said to develop 310 hp. and weigh 640 lb., or 2.06 lb. per horsepower.

The new engine is of the fixed radial cylinder type, air-cooled. At the recent convention of the Society of Automotive Engineers, Mr. Smith gave out many interesting details concerning his experimental work in developing the engine. He believes that the air-cooled engine will soon displace the water-cooled types, for aëronautic use.

During the first two years of the war, Mr. Smith explained, he was in England conducting experiments on fixed radial air-cooled engines for the British government. Two designs were perfected, and both have seen actual service. Official British reports regarding the ten-cylinder engine credit it with a fuel consumption of less than 0.50 lb. of gasoline per b.hp.-hr. and a lubricating-oil consumption of less than 0.02 lb. per b.hp.-hr., while the nine-cylinder engine is reported to use less than 0.45 lb. of fuel per b.hp.-hr. These figures indicate a remarkably high economy of operation.

There is a real necessity that the future responsible chief should shoulder responsibility without definite guidance at an early age. It may be said that few engineers begin their life work until thirty; the previous years are those of training, education, experience and guidance. The next decade establishes results and furnishes proof of ability under the increasing load. If at 50 the individual is not in responsible charge, it is safe to assume he will never get much further. Accumulation of knowledge is most rapid in the earlier years, but time is required for stability and balance, and responsibility accelerates these indispensable qualities. No one has ever finished learning until decay supervenes; in the school of experience we are all pupils. Some at 20 know virtually all they will ever acquire, subsequent experience is a permutation of the knowledge gained; in other cases atrophy of intellect is deferred to extreme old age.

Bituminous-Coal Production in 1918

All records of bituminous-coal production in the United States went by the boards during the year just closed, according to a statement issued by the National Coal Association Jan. 1. Official figures of the United States Geological Survey, supplemented by a conservative estimate by the National Coal Association for that portion of the year not yet recorded by the Government, place total bituminous-coal production in 1918 at 587,500,000 tons, an increase of approximately 36,000,000 tons, or nearly 7 per cent., over production in 1917, in itself a record.

The nation's war-time demand for coal, the heaviest in the country's history, has been met in full. The mining of this banner tonnage during 1918 also virtually insures the country against a repetition of the distressing shortage of bituminous coal experienced last winter. With fair operating conditions and intelligent distribution of the product, it is likely that there will be sufficient bituminous coal for the nation during the winter.

The year's record tonnage has been mined, under the spur of war-time necessity, with fewer men, generally, in the coal mines of the country than during 1917, when the output was materially lower. Increased efficiency of management, the patriotic desire of operators and employees to support the Government in prosecuting the war to the maximum of their ability, and a better car supply and movement under the operation of the United States Railroad Administration, are chiefly responsible for the increase in production.

A year ago the country faced an unprecedented coal shortage; today it faces the prospect of a sufficient bituminous-coal supply to meet its requirements. The change has been brought about by a year of the utmost activity, vigorous action and close coöperation with the United States Fuel Administration.

Personals

J. Paul Clayton, who has been associated with the Middle West Utilities Co., at Chicago, has been elected a vice-president of the Central Illinois Public Service Co., and has moved to Mattoon, Ill.

George H. Sharpe, who until recently was fuel engineer for the conservation department of the United States Fuel Administration, has become associated with Frame, Friend & Stineman, Inc., at New Haven, Conn.

Herbert B. Reynolds, formerly a fuel engineer in the United States Bureau of Mines, has returned to the motive-power department of the Interborough Rapid Transit Co., New York City, as mechanical research engineer.

Melvin B. Newcomb, formerly chief draftsman of the hydraulic department of the Wellman-Seaver-Morgan Co., Cleveland, Ohio, has been appointed chief engineer of the rubber machinery department at the Akron works of the same company.

Engineering Affairs

The New England Water-Works Association will hold a meeting at the Hotel Brunswick, Copley Square, Boston, Mass., on Feb. 12.

The American Society of Mechanical Engineers is to hold an organization dinner-meeting of the engineers in Havana, Cuba, on Feb. 22.

The San Francisco Section of the A. S. M. E. will hold a meeting at the Engineers' Club on Feb. 13. The subject will be on "The Present Status of Electrical Arc Welding," by F. A. Anderson, electrical inspector of the United States Shipping Board.

Miscellaneous News

The Westinghouse Electric and Manufacturing Co. has completed and opened the "Essington Club" for the exclusive comfort, convenience and entertainment of its employees at the Essington Works, South Philadelphia, Penn. The equipment of the establishment is of the most modern and the operation of the club is in charge of a special management. It is one of the largest places of its kind in the Delaware industrial section.

Martinsburg Power System—With the "tying-in" of the new transmission line Jan. 12 from the recently completed generating station at Dam No. 5, on the Potomac river, to the substation located at the Potomac Light and Power Co.'s steam plant, at Martinsburg the last link of the improved power system for Martinsburg, W. Va., was forged. This link completes the chain that connects the steam plant at Security, Md., and the hydro plant at Dam No. 5, with the steam plant at Martinsburg and the hydro plant at Dam No. 4. The line and plant construction has entailed the expenditure of vast sums of money and was built with the sole purpose of furnishing the City of Martinsburg and the immediate vicinity with the best electric service obtainable.

Business Items

Warren Webster & Co. announce the opening of an office at 805 Sumpter Building, Dallas, Tex., with W. B. Irwin in charge as district representative.

Butler and Hayes, Inc., have opened an office at 220 Devonshire St., Boston, Mass., as mechanical and chemical consultants and experimental engineers; and their testing laboratories are fully equipped for the study of industrial problems.

The American Bosch Magneto Corporation is the official name of the former Bosch Magneto Co., which was recently sold by the Alien Property Custodian of the United States to the highest bidder. The entire holdings and organization, including the Bosch works at Springfield, Mass., have been taken over and the large output will now be devoted entirely to the requirements of American manufacturers and the public.

The American Pipe Bending Machine Co., of Boston, is about to open up pipe-bending plants in all large cities throughout the country. The first plant is about ready for operation at Lowell, Mass. The company will make a specialty of furnishing bent pipe and make delivery of small orders in forty-eight hours notice. Each plant will have facilities for turning out from 1000 to 3000 bends per day, and will be in charge of an expert pipe bender.

Trade Catalogs

The Expanded Metal Engineering Co., of New York City, has recently issued a 40-page illustrated booklet entitled "Steelcrete Machine Guards," which contains much useful information regarding specifications and machine guard requirements for anyone desirous of installing machine guards. A copy of the booklet may be had upon request.

New Construction

PROPOSED WORK

Me., Portland—The Russell Shipbuilding Co. will rebuild its boiler plant and saw mill, recently destroyed by fire. Estimated cost, $25,000.

Mass., Belchertown—The Commonwealth of Massachusetts will install a steam heating system in the 2-story, 75 x 90 ft. dormitory which it plans to build at the Home for the Feeble-Minded here. Total estimated cost, $100,000. Address G. M. Kline, 36 State House, Boston, Dir. of Mental Diseases. Kendall, Taylor & Co., 94 Federal St., Boston, Arch.

Mass., New Bedford—H. T. Borden, Chn. of the Hospital Comn., 154 Fair St., will receive bids in the spring for the construction of a power house, laundry, etc., in connection with the group of hospital buildings which will be constructed on Mt Pleasant, Myrtle, Van Buren and Jefferson St. Total estimated cost, $100,000. J. R. Worcester & Co., 79 Milk St., Boston, Engr.

Mass., Rutland—The Central New England Sanitorium will build a 3-story, 40 x 90 ft. administration building and two 3-story, 35 x 100 ft. ward buildings. A steam-heating system will be installed in same. Total estimated cost, $250,000. B. T. Crane, Supt. E. F. Stercus, 9 Park St., Boston, Arch.

Conn., Hartford—The Johnson & Webster Co., 327 Trumbull St., will install a steam heating system in the 6-story, 40 x 126 ft. apartment hotel which it plans to build on Washington and Park St. Total estimated cost, $160,000. Russell F. Barker, 43 Ann St., Arch.

N. Y., Forest Hills—The Board of Education, 500 Park Ave., New York City, will install a steam heating system in the 2-story, 105 x 108 ft. public school building which it plans to construct here. Total estimated cost, $200,000. C. B. J. Snyder, Municipal Bldg., New York City, Arch.

N. Y., New York—The Board of Education, 500 Fifth Ave., will install a steam heating system in the 5-story, 60 x 142 ft. public school building which it plans to build on Tremont and Bryant Ave., Bronx Borough. Total estimated cost, $200,000. C. B. J. Snyder, Municipal Bldg., Arch.

N. Y., New York—The Board of Education, 500 Fifth Ave., will install a steam heating system in the 5-story, 118 x 192 ft. public school building, which it plans to build on Crotona Ave. and 181st St., Bronx Borough. Total estimated cost, $543,474. C. B. J. Snyder, Municipal Bldg., Arch.

N. Y., New York—B. F. Keith, 1564 Broadway, will install a steam heating system in the 3-story, 200 x 228 ft. theatre which he plans to build on Fordham Rd. and Valentine Ave., Bronx Borough. Total estimated cost, $300,000.

N. Y., Niagara Falls—The Hydraulic Power Co. has been authorized by the Public Service Commission to issue $2,000,000 bonds for extensions and improvements to its plant, to include the construction of an addition to power house No. 3, and the installation of new electric generating and hydraulic machinery. Noted Dec. 10.

Penn., Honesdale—The Honesdale Consolidated Heat, Light & Power Co. plans to build a 1-story electric power plant. Estimated cost, $50,000. F. H. Elsele, 110 Seventh St., Mgr.

Del., Wilmington—The Standard Kid Manufacturing Co., 4th and Monroe St., plans to build a 1-story, 40 x 60 ft., steam power plant. Estimated cost, $25,000. R. C. McMullen, Mgr., in charge. J. J. Kennedy, 925 Market St., Arch.

Md., Baltimore—The Western Maryland Dairy, 1125 Linden Ave., plans to build a 1-story, 49 x 74 ft. boiler house.

Md., Myersville—The Hagerstown & Frederick Railway Co., Terminal Bldg., Frederick, plans to rebuild its electric plant here, recently destroyed by fire. M. A. Poller, Frederick, Gen. Mgr.

Ga., Atlanta—The city plans to appropriate $70,000 for the construction of a generating plant. R. C. Turner, City Electrician.

Ga., Atlanta—The City Council plans an election March 5, to vote on $500,000 bond issue for improvements to the water-works, including installation of additional pumps. H. L. Collier, City Engr.

Ohio, Sandusky—David Olmstead, c/o H. L. Stevens, Arch., 910 South Michigan Ave., Chicago, Ill., will install steam heating system in the 6-story hotel which will be constructed here. Total estimated cost, $200,000.

Ohio, Toledo—The Toledo Railway & Light Co., Smith and Baker Bldg., plans to issue $3,200,000 bonds for the acquisition, construction, extension and equipping of additional property; also for improvements and extensions to the existing light and power plants. None of the money to be raised by these bonds is to be spent upon street railway property. F. R. Coates, Pres. and Gen. Mgr.

Ind., Gary—The Central Heating Co. plans to construct a large power house in connection with the heating plant which it will build on the high line railroad west of Broadway; first unit will be in operation by September. Estimated cost, $200,000.

Mich., Detroit—H. S. Starkey, Sec'y., Board of Commissioners, 232 Jefferson Ave., will receive bids until Feb. 10 for the construction of a 1-story, 54 x 90 ft. boiler house in the water-works park; boilers, monorail and beam in front of boilers, stokers and windbox will be installed in same.

Mich., Detroit—The Detroit Heat Treating Co., St. Paul and Bellevue St., will install electric motors in the 1 story, 43 x 55 ft. heat treating plant which it plans to build. Brown & Preston, 849-51 David Whitney Bldg., Arch.

Mich., Wyandotte—The city will receive bids until Feb. 18 for installing 2 pumps for immediate use (2 to be provided ultimately), 1 motor driven pump and 1 auxiliary motor and oil engine in connection with the improvements which it plans to the sewerage system in the western section of the city. Total estimated cost, $155,000. M. L. Brown & Co., 820 Chamber of Commerce, Detroit, Engr.

Ill., Aurora—The Trustees of the Second National Bank have awarded the contract for the construction of a 5-story bank building, to Hoggson Bros., 485 Fifth Ave., New York City, N. Y. A steam heating system will be installed in same. Total estimated cost, $100,000.

Ill., Chicago—The Acme Malting Co., 175 West Jackson Blvd., has had plans prepared for the construction of a 1-story power plant at Cortland St. and Kilbourne Ave. Estimated cost, $15,000.

Ill., Streator—D. C. Murray, 309 East Main St., will install a steam heating system in the 5-story, 50 x 142 ft. store and office building which he plans to build. Total estimated cost, $175,000. G. C. Nimmons & Co., 120 South Michigan Ave., Chicago, Arch.

Wis., Jim Falls—The American Public Utilities Co., Grand Rapids Savings Bank Bldg., Grand Rapids, Mich., plans to build a power house and dam here. Estimated cost, $2,000,000.

Minn., St. Paul—The Northern Pacific Mutual Benefit Association, 203 Railroad Bldg., will receive bids in March for the construction of a 4-story hospital and power plant, on Simpson and Edwards St. Estimated cost, $300,000. L. Bassindale, 321 Capital Bank Bldg., Arch. Noted Nov. 5.

Minn., Tyler—The city plans a $20,000 bond issue for the construction of an electric-light plant and water-works system.

Kan., Hiawatha—The city plans an election soon to vote on a bond issue of $25,000 for improvements to the water-works system, to include the installation of pumps at the spring on the county farm, also extending the transmission line to the city system. J. B. Liebengood, City Clk.

Neb., Norfolk—The State Legislature, Lincoln, has been petitioned to appropriate $35,000 for building an addition to power house and smoke stack at the State Institution here.

S. D., Watertown—The city plans to build and operate an electric-light and power plant of sufficient size to take over the lighting of the streets and parks, run the pumping machinery of the water-works. Estimated cost, $250,000.

Wyo., Manville—The town has granted franchise to E. P. Bacon Casper, to build and operate a heating, lighting and power system here.

Wyo., Thermopolis—The town has adopted a resolution to make application to the Wyoming Public Service Commission for a transferable franchise to build a municipal light and power system. This action was taken in connection with an application to the Wyoming Public Service Commission by the Hot Springs Light & Power Co., for increase in rates, which was opposed by town on grounds of poor service.

Mo., Kansas City—The Kansas City Light & Power Co., 1500 Grand Ave., plans to improve its plant. Estimated cost, $5,500,000. Hugh Blackwell, Vice-Pres.

Mo., St. Louis—Jos. Greenspans Sons, 67 Branch St., is in the market for a 20-hp. oil engine.

Okla., Shawnee—The city plans an election soon to vote on a $500,000 bond issue for the construction of a modern light and power plant.

Okla., Yale—The city has had plans prepared for extensions to the light and water systems, to include improvements to the power plant, power lines, stack, switchboard, engine and boiler equipment. G. B. Gelder, City Clk.

Colo., Lamar—The City Council has applied to the Colorado Utilities Commission for authority to construct an electric-light plant. If permit is granted an election will be held this spring to authorize bonds for same. W. C. Fee, City Atty.

Wash., Spokane—The city plans to install a refrigerating plant in connection with the alterations it plans to the city market on Wall and Trent St. Estimated cost, $10,000. L. L. Rand, Arch., Rookery Bldg., preparing plans.

Cal., Brandy City—The Brandy City Mining Co. plans to build a power plant to supply electricity to operate the machinery in its mines. The company also plans to build a 150 ft. dam on the North Yuba River below Bullards Bar.

Cal., Sacramento—The city plans to build an electrically-operated pumping plant at the water-works. Thomas Coulter, Comn. Pub. Works.

Ont., Newmarket—The city plans to install special pumping apparatus, thereby increasing the existing water supply. James, Loudon & Hertzberg, Excelsior Life Bldg., Toronto, Consult. Engr.

Ont., Pembroke—The Town Clerk will receive bids until March 7 for furnishing and installing 1 water-works pumping unit, to consist of turbine pump of 2000 gallons capacity against 330 ft. head and a steam turbine or gasoline engine directly connected to pump.

CONTRACTS AWARDED

N. Y., Brooklyn—E. Riegelman, Borough President, has awarded the contract for reserving and furnishing electric generating capacity, etc., during the year, to the Edison Electric & Illuminating Co., Pearl St. Estimated cost, $47,400.

N. Y., New York—F. L. Dowling, Borough President, has awarded the contract for reserving and furnishing electric generating capacity for use of high pressure fire service pumping station for the year, to the New York Edison Co., 130 East 15th St. Estimated cost, $48,600.

N. Y., New York—The New York Academy of Medicine, 17 West 43rd St., has awarded the contract for the construction of a 6-story, 25 x 100 ft. addition to the college, to M. Eidlitz, 30 East 42nd St. A steam heating system will be installed in same. Total estimated cost, $175,000.

N. Y., New York—Sperry & Hutchinson, 2 West 45th St., has awarded the contract for the construction of two 2-story, 105 x 200 ft. theatres on West 42nd St., between 7th and 8th Ave., to Thompson-Starrett Co., 49 Wall St. A steam heating system will be installed in same. Total estimated cost, $400,000.

N. J., Jersey City—The Pennsylvania R. R., Broad St. Station, Philadelphia, Penn., has awarded the contract for recovering power, heating and vacuum lines from the power house at Washington St. to the depot on Exchange Pl., to the W. W. Farrier Co., 44 Montgomery St.

N. J., Newark—Peter Hauck, 85 Clifton Ave., has awarded the contract for installing power equipment in his factory, to W. G. Sharwell, 377 North 5th St. Noted Feb. 4.

Minn., St. Paul—The Northern Pacific Mutual Benefit Association, 203 Railroad Bldg., has awarded the contract for installing a heating and ventilating system in the 4-story hospital which it plans to build on Simpson and Edmund St., to Neiler, Rich & Co., 1407 Manhattan Ave., Chicago, Ill. Total estimated cost, $300,000.

Cal., Sacramento—The Northern California Milk Producers' Association, California Fruit Bldg., has awarded the contract for the construction of a plant, to include power house, cold-storage plant, etc., to the Clinton Construction Co., 357 Pine St., San Francisco. Total estimated cost, $125,000.

N. B., Marysville—The Nashwaak Pulp & Paper Co. has awarded the contract for the construction of a large dam to supply power for their new mill, to the Ambursen Hydraulic Construction Co., 10 Cathcart St., Montreal, Que.

THE COAL MARKET

BOSTON—Current quotations per gross ton f.o.b. mines are as follows:

ANTHRACITE

	Circular Current		Circular Current
Buckwheat	$3.40	Boiler	$2.65
Rice	2.90	Barley	2.40

All rail to Boston is $2.86.

BITUMINOUS

Bituminous, $8 to $8.75.

Pocahontas and New River, f.o.b. Boston, $8.35 to $8.90.

NEW YORK—Current quotations per gross ton f.o.b. Tidewater at the lower ports* are as follows:

	Circular	Individual		Circular	Individual
Pea	$6.55	$7.30	Broken	$7.80	$8.55
Buck.	5.10	5.90	Egg	7.70	8.45
Rice	4.65	5.10	Stove	7.95	8.70
Barley	4.15	4.30	Chestnut.	8.05	8.80

BITUMINOUS

Current quotations, gross tons, based on Government prices at the mines, net ton; f.o.b., Tidewater, at the lower ports, are as follows:

	Mine Gross	F.O.B. N.Y. Gross
Central Pennsylvania (Mine run, Prepared or Slack)	$3.30	$5.45
Upper Potomac, Cumberland & Piedmont Fields:		
Run of Mine	3.08	5.23
Prepared	3.36	5.51
Slack	2.80	4.95

Quotations at the upper ports for both bituminous and anthracite are 5c. higher on account of the difference in freight rates, and are exclusive of the 3% war freight tax.

*The lower ports are: Elizabethport, Port Johnson, Port Reading, Perth Amboy and South Amboy. The upper ports are: Port Liberty, Hoboken, Weehawken, Edgewater or Cliffside and Guttenberg. St. George is in between and sometimes a special boat rate is made. Some bituminous is shipped from Port Liberty. The rate to the upper ports is 5c. higher than to the lower ports.

PHILADELPHIA—Prices per gross ton f.o.b. cars at mines for line shipment and f.o.b. Port Richmond for tide shipment are as follows:

	Line		Tide	
	Current	One Yr. Ago	Current	One Yr. Ago
Pea	$4.80	$3.40	$6.05	$4.30
Barley	2.40	1.90	3.30	2.15
Buckwheat	3.40	2.90	4.45	3.50
Rice	2.90	2.40	3.80	3.40
Boiler	2.70	2.20	3.70	3.30

CHICAGO—Steam coal prices f.o.b. mines:

	Illinois Coals	Southern Illinois	Northern Illinois
Prepared sizes	$2.55—2.70		$3.25—3.40
Mine-run	2.35—2.50		3.00—3.15
Screenings	2.05—2.30		2.75—2.90

BIRMINGHAM—Current prices per net ton f.o.b. mines are as follows:

	Mine-Run	Prepared Sizes	Slack or Screenings
Big Seam, Mary Lee, New Castle, Blue Creek, Brookdale, Milldale, Henry Ellen or Acmar	$2.45	$2.75	$2.40
Cahaba, Black Creek, Milldale, Carter and Durie seams, and Underwood seam in Etowah and Blount Counties, Jefferson seam in Marion, Walker and Winston Counties	3.45	3.75	3.10
Pratt, Brookwood, Nickel Plate, America, Jagger, Coal City, Jefferson (except in Walker, Marion and Winston Counties), Mt. Carmel seam or upper branch of Big Seam on Birmingham Mineral south of Bessemer	2.85	3.05	2.45
Helena and Harkness seams and coal mined by No. 2 Belle Helen, and Youngblood seam	2.90	3.20	2.70
Climax seam near Maylene.			

ST. LOUIS—Prices per net ton bituminous coal f.o.b. mine today as compared with a year ago are as follows:

	Williamson and Franklin Counties, Mt. Olive and Staunton	Standard
Prepared sizes (lump, egg, nut, etc.)	$2.55@2.75	$2.40@2.70
Mine-run	2.35@2.50	2.20@2.30
Screenings	2.17@2.32	1.50@1.50

Williamson-Franklin rate to St. Louis is $1.10.

other rates p. 95.